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ELEMENTS

OF

CHEMISTRY

AND

NATURAL HISTORY.

TO WHICH IS PREFIXED,

THE PHILOSOPHY OF CHEMISTRY.

BY A. F. FOURCROY.

FIFTH EDITION,
WITH NOTES,
BY JOHN THOMSON, SURGEON, EDINBURGH.

IN THREE VOLUMES.

VOL. I.

EDINBURGH:
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PART III.

CHAPTER VI.

IMPERFECT NEUTRAL SALTS, WITH BASE OF AMMONIAC, OR AMMONIACAL SALTS.

Ammoniacal ſalts are formed by the combination of an acid with *volatile alkali*, or ammoniac. Their taſte is generally urinous; they are all more or leſs volatile, and more eaſily decompoſed than the perfect neutral ſalts. We are acquainted with ſix different ſpecies: ammoniacal ſulphat; ammoniacal nitrat; ammoniacal muriat, or *ſal ammoniac*, properly ſo called; ammoniacal borat; ammoniacal fluat; and ammoniacal carbonat.

Species I. Ammoniacal Sulphat.

Ammoniacal ſulphat, formerly called *vitriolic ammoniacal ſalt*, or *ammoniacal vitriol*, is produced by a ſaturated combination of ſulphuric acid and ammoniac. It was termed *ſecret ammoniacal ſalt of Glauber*, becauſe this chemiſt was the firſt who diſcovered it.

This ſalt, when very pure, appears under the form of needles, which, when carefully examined, are flattened priſms, with ſix ſides, two of which are very large, terminated by pyramids with ſix faces, more or leſs irregular; but this form exhibits varieties which are different from thoſe we have deſcribed. This ſalt ſometimes occurs in the form of quadrangular priſms: I have often obtained it in ſquare and very thin plates. This form ſeems to depend, as in every inſtance of cryſtallization, on the manner in which the ſaline particles are depoſited, which is either leſs regularly on each other, or according to the law of their decreaſe.

The taſte of this ſalt is bitter and urinous, it is very light and very friable.

As it contains much water of cryſtallization it melts at firſt with a very ſlight fire, but it becomes gradually dry in proportion as its water of cryſtallization is diſſipated. In this ſtate it begins to redden, and melts ſpeedily, without being volatilized, according to Bucquet, though Baumé aſſerts that it is ſemivolatile. I have obſerved, in repeating this experiment, that a portion of the ſalt ſublimes, the reſt remaining fixed in the veſſel. Bucquet, doubtleſs, means to ſpeak of this laſt [a].

Sulphat of ammoniac is ſcarcely changed by expoſure to air; it does not effloreſce like ſulphat of ſoda, but, on the contrary, ſlightly attracts the humidity of the air.

It is very ſoluble in water; two parts of cold, or one of hot water, being ſufficient to hold it in ſolution: it cryſtallizes by cooling; but the fineſt cryſtals are obtained by ſpontaneous evaporation. It likewiſe unites with ice, which it melts, producing at the ſame time an exceſſive degree of cold. It does not act on ſilicious and aluminous earths; magneſia ſeems to decompoſe it after a length of time, as Bergman obſerves.

Lime, barytes, and pure fixed alkalis diſengage the ammoniac, as we ſhall likewiſe ſee in muriat of ammoniac; if carbonat of potaſh or ſoda be diſtilled with ſulphat of ammoniac, a double decompoſition and combination take place. The ſulphuric acid unites with the fixed alkali, and forms either ſulphat of potaſh or of ſoda. The carbonic acid, at the ſame time, being volatilized, together with the alkaline gas or ammoniac, both unite and form a peculiar ammoniacal ſalt, which cryſtallizes in the recipient. We ſhall ſpeak more fully on this ſubject in the hiſtory of muriat of ammoniac [b].

The nitric and muriatic acids ſeparate the ſulphuric acid of the ſulphat of ammoniac, in the ſame manner as from the ſulphats of potaſh and ſoda.

It has not hitherto been found in nature; yet we find in the *Cryſtallographie* of Romé de Liſle, 1772, page 57. that according to Sage, the native ſal ammoniac of volcanos is of this kind. It is artificially produced by the direct combination of the ſulphuric acid, and ammoniac, or by decompoſing earthy or metallic ſalts, by means of volatile alkali; or laſtly, by the decompoſition of nitric, muriatic, and carbonic ammoniacal ſalts by the ſulphuric acid.

Sulphat of ammoniac is of no uſe, though Glauber recommends it ſtrongly, for metallurgic operations [c].

Species II. Nitrat of Ammoniac.

Nitrat of ammoniac, or nitrous ammoniacal ſalt, is alſo a production of art, prepared by the direct combination of the nitric acid with ammoniac; its cryſtals are priſms, whoſe figure has not been accurately deſcribed. Romé de Liſle affirms, that it cryſtallizes in fine needles, reſembling thoſe of ſulphat of potaſh; but they are in fact very long and ſtriated, and reſemble common nitre more than ſulphat of potaſh.

Its taſte is bitter, penetrating, and urinous. It is friable like ſulphat of ammoniac. When expoſed to the action of fire it liquifies, gives out aqueous vapours, becomes dry, and, long before the red heat, detonates alone without the contact of any inflammable matter, and even in a cloſe veſſel. In the firſt edition of this work we obſerved, that this ſingular property appeared to depend on the ammoniac, becauſe alkaline gas ſeems to be in ſome degree combuſtible, and becauſe it augments the flame of candles before it extinguiſhes them. Berthollet having expoſed nitrat of ammoniac to the action of heat in a pneumato-chemical and diſtillatory apparatus, and having obſerved the phenomena of this operation more carefully than had been done before, remarks, that it is not a true detonation which takes place, but a ſudden and inſtantaneous decompoſition, in which part of the volatile alkali or ammoniac is entirely deſtroyed. The water obtained in the receiver contains a ſmall part of the nitric acid diſengaged in proportion to the quantity of ammoniac decompoſed; and the latter gives out azotic gas or atmoſpheric mephitis. The liquid product of this operation being weighed, a greater quantity of water is found than exiſted in the nitrat of ammoniac; and Berthollet thinks that this ſuperabundant water is formed by the union of hydrogen, which is one of the principles of ammoniac, with the oxygen of the nitric acid. The azot, or other principle of ammoniac, which is ſix times more in quantity in this ſalt than the hydrogen, is diſengaged and collected under the veſſels of the pneumatic apparatus, under the form of azotic gas.

It is not known whether this ſalt be fuſible, for the firſt liquifaction is owing to its water of cryſtallization, and it is diſſipated before it can be made to undergo a ſecond.

The ſame may be remarked of its volatility, for it ſwells and is decompoſed before it can be ſublimed.

It ſlightly attracts the humidity of the air, which agglutinates its cryſtals, and forms it into clots or balls.

It is very ſoluble in water; unites with, and melts ice, producing a conſiderable degree of cold. Half its weight of hot water is required to diſſolve it, and a ſomewhat greater of cold; it cryſtallizes irregularly by cooling, but the moſt perfect cryſtals are obtained by ſpontaneous evaporation.

Nitrat of ammoniac is decompoſed by barytes, lime, and fixed alkalis. The alkaline gas ſeparated by theſe cauſtic ſubſtances, being very volatile and expanſible, the decompoſition of nitrat of ammoniac, as well as of other ſalts of this kind, is practicable in the cold, and may be effected by triturating this ſalt with lime; but when the decompoſition is intended to be made in cloſe veſſels, by means of fire, the heat muſt be very carefully regulated, to avoid ſpontaneous combuſtion.

The ſulphuric acid diſengages the nitric acid from this ſalt with effervеſcence, and forms ſulphat of ammoniac, with its baſe [d].

The carbonats of potaſh and ſoda decompoſe it by double affinity, and in the operation a concrete volatile alkali is ſublimed, which we ſhall examine under the name of *carbonat of ammoniac*.

The nitrat of ammoniac is not applied to any uſe.

Species III. Muriat of Ammoniac, or Sal Ammoniac.

Ammoniacal muriat is a ſaturated combination of the muriatic acid with ammoniac. The ancients diſtinguiſhed it by the name of *Sal Ammoniac*, becauſe they received it from that part of Lybia, in which the temple of Jupiter Ammon was ſituated.

This ſalt is found native in the vicinity of burning mountains, where it has the form of an eſfloreſcence, or groups of needles, either ſeparate or together, uſually of a yellow or red colour, and mixed with arſenic and orpiment. This is not uſed, the factitious ſort prepared in the large way being the only ſort met with in commerce.

The true origin of this ſalt was not known till the commencement of the preſent century, though the ſalt itſelf has been uſed from time immemorial. By a letter of Mr. Lemere, conſul at Cairo, written to the Academy, the 24th of June 1719, we became acquainted with the art of obtaining ſal ammoniac from the ſoot of camel's dung, which is burned at Cairo inſtead of wood[e]. This ſoot is put into large round bottles, a foot and a half in diameter, terminated by a neck two inches high, which is filled to within four inches of the neck; each bottle contains about forty pounds of this ſoot, and affords nearly ſix pounds of the ſalt. Theſe veſſels are placed on a furnace, ſo formed, that the neck only is expoſed to the air; a fire is made with camel's dung, and continued for three days and three nights; and the ſalt ſublimes on the twelfth or thirteenth day. The bottles are then broken, and the loaves of ſal ammoniac are taken out; theſe loaves, which we receive in the form they obtain from the ſubliming veſſels, are convex and unequal, having a protuberance on one ſide formed from the neck of the ſubliming veſſel. The inferior as well as the ſuperior ſurface is ſoiled by a kind of ſoot.

Pomet has deſcribed a kind of ſal ammoniac in loaves ſimilar to thoſe of ſugar, with the point cut off, which is imported by the way of Holland. Geoffroy, who firſt diſcovered in France the materials of this ſalt, and conjectured the proceſs employed for its preparation, diſcovered likewiſe, that this ſecond kind of ſal ammoniac is made in the Indies, where it is prepared in much larger quantities than in Egypt, from which it differs only in its form, being likewiſe ſublimed. Theſe loaves, of fourteen or fifteen pounds each, are hollow at their baſe, and formed of three different layers. The cone is truncated, becauſe the point, conſiſting of impure matter, has been cut off.

Baumé has eſtabliſhed a manufacture of muriat of ammoniac in the neighbourhood of Paris, where this ſalt is entirely compoſed by a different proceſs from that of the Egyptians, who only extracted it. Baumé's ſalt is much purer than the Egyptian *.

The taſte of muriat of ammoniac is penetrating, acrid, and urinous. The form of its cryſtals is a long hexahedral pyramid; the feathered form conſiſts of a number of theſe pyramids joined together under various angles. Romé de Liſle thinks that the cryſtals of muriat of ammoniac are octahedrons joined together. Cubical cryſtals of this ſalt are formed, though rarely, in the middle of the concave and hollow parts of the loaves formed by ſublimation.

This ſalt poſſeſſes a ſingular phyſical property, namely, a kind of ductility or elaſticity, ſo that it rebounds under the hammer, and may be bended; a circumſtance which renders it difficult to pulverize.

Muriat of ammoniac is entirely volatile, but requires a conſiderable heat to raiſe it. This method is uſed in order to procure it in a ſtate of purity, and perfectly dry. It is pulverized, and placed in matraſſes plunged up to their middle in a ſand bath; heat being gradually applied for ſeveral hours, the ſalt ſublimes, and forms a maſs compoſed of ſtriated needles joined to each other length-ways. When the operation is well managed, regular cubical cryſtals are often found in the middle of the loaf; but if the heat is too great, the maſs is denſe, ſemi-tranſparent, and as if melted.

Baumé has obſerved, that when this ſalt is ſublimed ſeveral times, there is each time diſengaged a ſmall quantity of ammoniac and muriatic acid; ſo that it may perhaps be poſſible by repeated ſublimations to decompoſe muriat of ammoniac entirely: this fact requires to be confirmed.

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* Sal ammoniac is now made in large quantities in Britain. The volatile alkali is obtained in an impure liquid ſtate from ſoot or bones, or any other ſubſtance that affords it; to this the ſulphuric acid is added: and the ſulphat of ammoniac thus produced, is decompoſed by muriat of ſoda by double affinity; the ſulphuric combining with the mineral alkali, and the muriatic acid with the volatile alkali. The liquor therefore contains ſulphat of ſoda and muriat of ammoniac, which are ſeparated by cryſtallization; and the muriat of ammoniac is ſublimed into cakes for ſale. The cheapneſs of the ſulphuric acid, and of common ſalt, is the cauſe why they are made uſe of inſtead of the muriatic acid, with which the muriat of ammoniac might have been directly formed.

Lord Dundonald extracts volatile alkali from pit coal; but whether it can be afforded cheaper for the general purpoſes of commerce than that of the above proceſs, is not, I believe, yet aſcertained. T.

The muriat of ammoniac is not ſenſibly changed by expoſure to air, but may be kept for an unlimited time without alteration. It is very ſoluble in water, ſix parts of cold water diſſolving one of the ſalt, and a conſiderable degree of cold being produced. The cold is much greater when the ſalt is mixed with ice. This artificial cold cauſes ſeveral phenomena, which cannot be exhibited at pleaſure by any other means, ſuch as the congelation of water, the cryſtallization of certain ſalts, the fixation of evaporable fluids, &c.

Boiling water diſſolves nearly its own weight of muriat of ammoniac; the ſalt cryſtallizes by cooling; but, like other ſalts, the beſt cryſtals are obtained by ſpontaneous or inſenſible evaporation. A very ſaturated ſolution of this ſalt being cloſed in a bottle, frequently depoſits, at the end of ſome days, cryſtals in the form of a plume of feathers, compoſed of a middle fibre, to which a great number of other fibres are joined perpendicularly; and theſe laſt ſuſtain others which are ſmaller, in ſuch a manner, that the whole perfectly reſembles vegetation. I have often obſerved this phenomenon in my laboratory *.

Muriat of ammoniac is not decompoſed by alumine; neither does magneſia decompoſe it, but with difficulty, and in part, as Bergman obſerves: if a mixture of magneſia and ſolution of muriat of ammoniac be put into a bottle, vapours of ammoniac, according to the remark of the celebrated chemiſt of Upſal, are diſengaged at the end of ſome hours. But this diſengagement ſoon ceaſes, and the quantity of ſal ammoniac which is decompoſed is very ſmall.

Lime, and likewiſe barytes, ſeparate the ammoniac from the muriatic acid, even in the cold: if this ſalt be triturated with quick-lime, the ſtrong ſmell of ammoniacal gas is immediately

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* Every chemiſt muſt know how neceſſary it is to viſit from time to time the products preſerved in a laboratory, eſpecially ſaline ſolutions. When curious facts caſually offer themſelves, they ought to be immediately recorded to prevent their being loſt, together with the important conſequences to which they often lead. I have in very many inſtances obſerved cryſtals formed in this way, where none were obtainable by evaporation. It likewiſe happens not unfrequently, on opening bottles which have ſtood for ſome time, cryſtals are depoſited, whoſe origin is ſingularly favoured by agitation and the contact of air. This note, which is ſuperfluous to ſuch as are already in the habit of chemical obſervation, is inſerted for the uſe of beginners. *Note of the Author.*

perceived. When this operation is performed in cloſe veſſels, the ammoniac may be collected. But this operation, not having been accounted for by authors in as accurate a way as the modern diſcoveries permit, we ſhall proceed to give a more minute deſcription. If newly made quick-lime and very dry muriat of ammoniac be heated in a retort, whoſe neck is plunged beneath a veſſel of mercury, a large quantity of alkaline gas, or ammoniac, is obtained. This is known to be the cauſe why, in diſtilling without the pneumato-chemical apparatus, the product obtained is inconſiderable, at the ſame time that there is great danger of burſting the veſſels. This danger ariſes from the rarification of the ammoniacal gas which is diſengaged. Baumé, to prevent theſe inconveniencies, adviſes, that water be put into the retort. This fluid abſorbs, indeed, a part of the gas; but as the ammoniacal gas is much more volatile than the water, a large quantity is always loſt. Chemiſts, who are acquainted with the great affinity of ammoniacal gas for water, and its ſingular volatility, now employ the apparatus of Woulfe with the greateſt ſucceſs in the diſtillation of ammoniac. This apparatus, as we have before obſerved, conſiſts of a receiver with two necks, one adapted to the retort, and the other connected with an empty bottle; from which laſt collateral tubes iſſue, and are inſerted through the necks of additional bottles, which have likewiſe collateral tubes of communication ſimilar to the firſt, for the purpoſe of connecting additional bottles of the ſame kind. The mixture of quick-lime and dry muriat of ammoniac in powder is put into a ſtone-ware retort, and a gradual heat is cautiouſly applied, and increaſed to redneſs, ſo as even to vitrify the bottom of the retort. The ammoniacal gas diſengaged by the lime, paſſes into the receiver and the bottles, and uniting with heat to the water in the latter, ſaturates it, and forms the moſt highly cauſtic alkaline ſpirit. By this means no part of the ammoniac is loſt: the product is very pure and white, and the proceſs may be conducted to the beſt advantage, without any inconvenience to the operator from the fumes, or danger from the probable rupture of the veſſels. The late Bucquet and myſelf have aſcertained, that inſtead of three parts, as commonly directed, one part and a half of lime is ſufficient to decompoſe one part of muriat of ammoniac. Lime ſlacked in the air decompoſes this ſalt as well as quick-lime; the reſidue is calcareous marine ſalt, which we ſhall hereafter examine. It is proved by this operation, that lime has a ſtronger affinity than ammoniac to the muriatic acid.

The two fixed alkalis decompoſe muriat of ammoniac as well as lime, and diſengage the pure ammoniac in the gaſeous form; they may be employed with the ſame ſucceſs as lime; but the expence of theſe being much greater than that of the ſalino-terreſtrial ſubſtance, and no greater advantages ariſing from the uſe of them than of this laſt, they are never uſed for this purpoſe.

The ſulphuric and nitric acids ſeparate the muriatic acid from this ſalt by ſtronger affinity; and, by uniting with the ammoniac, compoſe ſulphat and nitrat of ammoniac.

Neutral ſalts have no effect on muriat of ammoniac, thoſe only excepted which are formed by the carbonic acid, and two fixed alkalis, which decompoſe it. A double decompoſition takes place in theſe mixtures: while the muriatic acid unites to the fixed alkali to form the muriats of potaſh and ſoda, the carbonic acid being diſengaged, ſeizes the ammoniac, and forms with it carbonat of ammoniac, which ſublimes in cryſtals, ſo as to line the interior part of the receiver. To perform this operation, one part of very dry carbonat of potaſh or ſoda is mixed with one part of ſublimed muriat of ammoniac in powder. The mixture is introduced into a ſtone-ware retort, to which a large receiver or cucurbit of glaſs is fitted; and a gradual heat being applied till the bottom of the retort becomes red hot, a very white cryſtallized ſalt ſublimes, which is the carbonat of ammoniac. A ſmall quantity of moiſture likewiſe paſſes over; the reſidue is muriat of potaſh or of ſoda, according to the alkali made uſe of. A very conſiderable quantity of this ſalt, equal in weight to nearly two-thirds of the muriat of ammoniac made uſe of, is obtained. This phenomenon cauſed Duhamel to conclude, that ſome of the fixed alkali paſſed over it with the volatile alkali. It is eaſy to conceive, ſince this theory has been explained by modern experiments, that it is to the carbonic acid of the fixed alkali, which unites with the ammoniac, that we are to aſcribe the large quantity of ſublimed ſalt which is formed. The concrete volatile alkali has nevertheleſs, till very lately, been eſteemed in a ſtate of purity, and the properties of cryſtallizing and of effervеſcing with acids, have been aſſumed as ſpecific characters; while the alkali obtained by lime, which is truly the pure volatile alkali, was ſuppoſed to be the ſame ſalt altered, and partly decompoſed. Hence we may ſee how much the diſcoveries of Dr. Black have elucidated the theory of ſaline matters: it may even be affirmed, that they have created a new theory of chemiſtry.

The uſes of muriat of ammoniac are very numerous and extenſive. It is uſed internally, in doſes of a few grains, in obſtructions, intermitting fevers, &c. Externally, it acts as a powerful antiſeptic in gangrenes, &c.

It is uſed in a great number of arts, but eſpecially in the art of dying, and in the art of ſoldering or uniting different metals. It is employed by braziers to cleanſe the ſurface of copper previouſly to its being tinned.

Species IV. Borat of Ammoniac.

The borat of ammoniac, or the ſaturated combination of boracic acid with ammoniac, has not yet been examined by any chemiſt; but I have myſelf made the following obſervations.

Very pure boracic acid being diſſolved in cauſtic volatile alkali or ammoniac, until the ſaturation appeared complete, was then diluted with a ſmall quantity of water, and about half the liquid evaporated on a ſand bath; a pellicle of united cryſtals was formed, whoſe ſurface exhibited the figure of polyhedral cryſtals. Its taſte was penetrating and urinous; it converted ſyrup of violets to a green, and gradually loſt its cryſtalline form, and became brown by expoſure to air. It is moderately ſoluble in water, and lime diſengages the ammoniac.

Such are the principal properties I have obſerved on a firſt examination; but I have not yet made a ſufficient number of experiments to ſpeak deciſively reſpecting its nature.

Borat of ammoniac is not applied to any uſe.

Species V. Fluat of Ammoniac.

This ſalt, like the foregoing, has not been accurately examined.

Boulanger agrees with Scheele in affirming, that the fluoric acid, combined with ammoniac, does not cryſtallize, but forms a gelly, which affords vapours reſembling thoſe of the muriatic acid, when the ſulphuric acid is added. Theſe two chemiſts have not examined the other properties of this kind of ſalt, but their obſervations were ſufficient to enable them to diſtinguiſh the fluoric from the muriatic acid.

Species VI. Carbonat of Ammoniac.

We give the name of carbonat of ammoniac to that which was formerly called *concrete volatile alkali*, and is a true neutral ſaline combination of the carbonic acid with ammoniac.

It does not exiſt pure and alone in nature. Moſt animal ſubſtances afford it by the action of heat. It is likewiſe formed by the direct union of ammoniac with the carbonic acid, 1*ſt*, Either by agitating the alkali in the upper part of a vat of fermenting liquor: 2*dly*, By paſſing the carbonic acid into volatile alkaline ſpirit: or, 3*dly*, By pouring the acid into a veſſel, on the ſides of which a few drops of ammoniac diſſolved in water are ſpread: 4*thly*, By combining directly over mercury carbonic acid gas and ammoniac. Theſe two gaſes immediately unite; much heat is extricated, and a concrete ſalt is formed on the ſides of the veſſel in which the mixture is made. In all theſe caſes, cryſtals of ammoniacal carbonat are formed. It is likewiſe obtained by decompoſing ammoniacal muriat, by the addition of carbonic neutral ſalts, with baſe of potaſh or ſoda.

It is capable of a regular form, and its cryſtals appear to be polygonal priſms. Bergman deſcribes them as octahedrons, having four of their angles truncated. Romé de Liſle mentions groups of cryſtals of this ſalt, in which it had the form of ſmall flattened tetrahedral cryſtals, terminated at their upper extremity with a dihedral ſummit.

Its taſte is urinous, but much leſs ſo than that of pure and cauſtic ammoniac; its ſmell, though ſimilar to this laſt, is likewiſe fainter: it converts ſyrup of violets to a green. We think it neceſſary to obſerve, with reſpect to this laſt property, that the carbonic acid does not completely deſtroy the properties of the alkalis with which it is combined; and that this is no reaſon why the appellation of neutral may not properly be applied to alkalis ſaturated with this weak acid.

Carbonat of ammoniac is very volatile, and the ſmalleſt heat ſublimes it entirely, if it be well cryſtallized. The firſt effect of heat is that of liquefaction, by means of its water of cryſtallization, or the aqueous fuſion, but it riſes immediately after, or nearly at the ſame time; ſo that it is ſcarcely poſſible to obtain this ſalt well cryſtallized, and at the ſame time very dry.

It is very ſoluble in water, and, like all other neutral ſalts, produces cold; a property ſo contrary to that of pure ammoniac, as to afford an additional argument for ranking it among the neutral ſalts. Two parts of cold water diſſolve more than one of carbonat of ammoniac; hot water diſſolves more than its own weight; but as this ſalt is diſſipated by the heat of boiling water, the method of cryſtallizing by heat cannot be uſed without riſking the loſs of a great part.

It ſlowly attracts moiſture from the air, eſpecially when it is not entirely ſaturated with carbonic acid.

The ſilicious and aluminous earths have no more action on this than on other ammoniacal ſalts: magneſia decompoſes it very weakly; lime decompoſes it by ſeizing its acid, with which it has a ſtrong affinity. If lime-water be poured into a ſolution of carbonat of ammoniac, a precipitate is immediately formed, and a ſtrong ſmell of volatile alkali is perceived. The lime ſeizes the carbonic acid, and forms chalk, or calcareous carbonat, which falls down, and the ammoniac is diſengaged: quick-lime being triturated with carbonat of ammoniac, the ammoniac is immediately diſengaged in a gaſeous form. If this mixture be put into a retort, the cauſtic ammoniac is obtained, in the ſame manner as from muriat of ammoniac, by the ſame intermedium; the apparatus of Woulfe being uſed. This fact proves, that lime has a ſtronger affinity than ammoniac with the carbonic acid: and other facts prove the ſame thing with regard to other acids.

The fixed alkalis decompoſe carbonat of ammoniac in the ſame manner as lime, by ſeparating the pure ammoniac, and uniting with its acid.

Laſtly, The ſulphuric, nitric, muriatic, and fluoric acids, have a ſtronger affinity than the carbonic acid to ammoniac: when one of theſe acids is poured on the carbonat of ammoniac, a ſtrong effervеſcence ariſes from the diſengagement of the carbonic acid. If this decompoſition be made in a tall ſlender veſſel, the preſence of the carbonic acid gas may be obſerved by the extinction of a lighted candle, the reddening of the tincture of turnſole, or the precipitation of lime-water immerſed in a ſmall cup below its orifice. Theſe decompoſitions of the carbonat of ammoniac by lime and fixed alkalis, which ſeize its acid and ſeparate the ammoniac, and by acids which ſeize the alkali and diſengage the carbonic acid, clearly ſhow the nature of this ſalt. Bergman has found, by accurate experiments, that a centenary of this ſalt contains forty-three parts of ammoniac, forty-five parts of carbonic acid, and twelve of water. From the conſideration that this ſalt contains a larger proportion of acid than carbonat of ſoda, and this laſt a larger quantity than carbonat of potaſh, he concluded, that the weaker the alkaline baſe, the more carbonic acid will be required for its ſaturation. The acid of borax does not decompoſe the carbonat of ammoniac in the cold; but when the latter is poured on a hot ſolution of boracic acid, a very ſenſible effervеſcence is produced, and the diſengagement of carbonic acid is ſhown by the uſual methods; a true borat of ammoniac being alſo found at the bottom of the veſſel. This experiment, which I have frequently repeated, proves, that heat modifies or changes the laws of affinity, or elective attraction, as Bergman has obſerved.

The carbonat of ammoniac does not act on the perfect neutral ſalts. We ſhall ſee that it decompoſes neutral calcareous ſalts, by the way of double affinity, which the pure and cauſtic ammoniac cannot effect. The valuable diſcoveries of Black explain why chemiſts were miſtaken in affirming, that ammoniac has a ſtronger affinity than calcareous earths with acids.

The carbonat of ammoniac is employed in medicine as a ſudorific, anti-hyſteric, &c. It is mixed with certain aromatic matters. It has been conſidered as a ſpecific againſt the bite of vipers; but the Abbé Fontana, with great reaſon, combats this opinion. Many have adviſed the uſe of the carbonat of ammoniac, or concrete volatile alkali, as a remedy in venereal diſorders; experience, however, has not yet decided on this head. All the knowledge the art of medicine poſſeſſes with regard to this ſalt is, that it is purgative, opening, diuretic, diaphoretic, diſcuſſive, and that it has a good effect in ſuch diſorders as depend on the denſity of the lymph; as certain venereal caſes, coagulations of milk, ſcrophulous diſorders, &c. It is adminiſtered in doſes of a few grains, in a proper vehicle, or compounded with opium.

CHAPTER VII.

GENUS III. Calcareous Neutral Salts.

Species I. Sulphat of Lime, Selenite, Gypſum.

THE combination of the ſulphuric acid with lime, ought to be denominated calcareous ſulphat; it is termed *ſelenite*, *plaſter*, or *gypſum*. This ſalt exiſts in large quantities in nature; it often forms immenſe tracts, or beds, as may be obſerved at Montmartre, near Paris. The mountains of this diſtrict are entirely filled with beds of ſelenite, or plaſter, covered with a kind of argillaceous marl, which almoſt always accompanies it.

Naturaliſts have long conſidered this ſalt as an earthy ſubſtance, on account of its want of taſte and ſolubility; it is diſtinguiſhed into many varieties, on account of the diverſity of its forms and ſtate of purity; the principal are here enumerated.

1. Sulphat of lime, or, Selenite in rhomboidal laminæ.

2. Sulphat of lime, or, Cuneiform ſelenite, or of the figure of arrow-heads.

It conſiſts of two ſcalene triangles, joined in the middle, each being compoſed of triangular laminæ, according to the obſervation of De la Hire. It is called *lapis ſpecularis*, *aſſes mirror*, or *talc of Montmartre*. Theſe two firſt varieties are fragments of large cryſtals, and are formed by the hand of man. They are mentioned here only as being ſpecimens for the cabinet.

3. Sulphat of lime, or, Selenite in decahedral rhomboids.

The quarries of Paſſy afford this ſort.

4. Sulphat of lime, or, Selenite in decahedral priſms.

It is formed of hexahedral priſms, terminated by dihedral pyramids, or by a concave angle; it is found in Switzerland, &c. and reſemble much the preceding variety.

5. Sulphat of lime, or, Selenite in cock's combs from Montmartre.

It conſiſts of a collection of ſmall lenticular cryſtals, placed obliquely beſide each other, and is formed by the union of the cryſtals deſcribed No. 2.

6. Sulphat of lime, or, Silky, or ſtriated ſelenite; ſilky gypſum of China.

It is found in Franche-Comté, Angoumois, &c. It is formed by the union of ſlender priſms, which are moſt commonly brilliant, and of the appearance of ſatin. It is very difficult to obſerve the rhomboidal laminæ, which are found in all the other varieties.

7. Sulphat of lime, or, Common gypſum, or plaſter ſtone.

This ſubſtance is white, more or leſs inclining to grey, interſperſed with ſmall brilliant cryſtals, eaſily cut with a knife. It is found diſpoſed in ſtrata, and forms moſt of the mountains in the vicinity of Paris. We ſhall hereafter find, that it is not pure ſelenite, but owes its moſt valuable property, as plaſter, to the admixture of another kind of earth.

8. Sulphat of lime, or, Gypſeous alabaſter.

This is a kind of plaſter ſtone, harder and more ancient than the foregoing, from which it differs only in being ſemi-tranſparent, of a yellowiſh grey, and in its laminated form or ſtructure apparently conſiſting of ſmall plates. It is found in great plenty at Lagny, near Paris. This is one of the whiteſt kinds; but it has ſometimes yellow, grey, violet, or black ſpots or veins.

9. Sulphat of lime, or, Selenite, common gypſum, or gypſeous alabaſter variouſly coloured, veined, ſpotted, clouded, or punctuated.

This mixture of colour ſhows, that the ſelenite is contaminated by ſome foreign ſubſtance. The colours are almoſt always occaſioned by iron.

Calcareous ſulphat is likewiſe found diſſolved in waters, as in the well-waters of Paris; it is never pure, but is always combined with ſome other earthy ſalt, with baſe of lime or magneſia.

We have already obſerved that calcareous ſulphat has long been taken for an earthy ſubſtance by naturaliſts, on account of its poſſeſſing no apparent degree of taſte or ſolubility; it has nevertheleſs a peculiar taſte, which it communicates to water, and which is very ſenſible on the ſtomach. Selenitical waters occaſion a very evident ſenſation of cold and weight in the bowels. The ſolubility, form, tranſparency, quantity, and eſpecially the diſpoſition in beds or ſtrata of cryſtallized ſelenite, more eſpecially in the environs of Paris, ſufficiently ſhow, that it has been originally diſſolved in water, and afterwards depoſited by that fluid.

Calcareous ſulphat, expoſed to the action of heat, loſes its water of cryſtallization, and decrepitates if the heat be ſuddenly applied; it is then of an opaque white, and friable, in which ſtate it is called *fine plaſter*, or plaſter of Paris, and is capable of aſſuming a certain conſiſtence with water. Very white and beautiful ſtatues of this ſubſtance are caſt in moulds; but the plaſter quickly becoming dry, and retaining but a ſmall proportion of water, they are very eaſily broken. If the heat be conſiderably raiſed, when the calcareous ſulphat has taken the form of a white powder, it fuſes into a kind of glaſs; but this effect is not produced but by a very ſtrong degree of heat, ſuch as is produced in the porcelain furnaces, or in the focus of burning lenſes. D'Arcet and Macquer ſucceeded in fuſing calcareous ſulphat; the latter obſerved, that when the cuneiform ſelenite is expoſed to the focus of a burning mirror, ſo that the light may fall on its poliſhed ſurfaces, it only becomes white: but if the edges be preſented, it immediately melts and boils up. It may likewiſe be melted by the blow-pipe, and by a ſtream of vital air thrown on burning charcoal.

Calcareous ſulphat placed on a hot iron becomes phoſphoric, a property which is common to all calcareous ſalts, and is likewiſe exhibited by lime during its extinction, as we have already remarked.

Calcareous ſulphat ſuffers no obvious alteration by contact of air; nevertheleſs, the poliſhed and brilliant laminæ of this earthy neutral ſalt become tarniſhed with the colours of the rainbow, ſplit or ſcale off, and are at length deſtroyed by the atmoſphere; but theſe phenomena ariſe from the united action of heat, water, and air.

Calcareous ſulphat is ſoluble in water, though in a degree ſcarcely ſenſible, according to the chemiſts of Dijon. About five hundred parts of water are required to diſſolve one of ſelenite. Hot water does not diſſolve a greater quantity. When this ſolution is evaporated, cryſtals are obtained, not ſimilar to thoſe found in nature, but in the form of ſmall plates or needles, which are precipitated in proportion as the liquor evaporates. The laminæ afforded by the evaporation of a ſolution of calcareous ſulphat are often brilliant, and, when minutely examined, are found to conſiſt of very ſmall needles united length-ways.

Barytes has more affinity than lime to the ſulphuric acid, and decompoſes calcareous ſulphat. If a ſolution of barytes be poured into water, loaded with this ſalt, ſtriæ of barytical ſulphat or ponderous ſpar are formed.

The fixed alkalis likewiſe decompoſe this neutral ſalt: when cauſtic fixed alkali is poured into a ſolution of calcareous ſulphat, a white precipitate, apparently mucilaginous, falls to the bottom in flakes, which is found by experiment to be quick-lime.

If the ſupernatant liquor be evaporated, ſulphat of potaſh or ſoda, according to the nature of the alkali made uſe of, is obtained.

Ammoniac, which has leſs affinity than lime with every acid, does not decompoſe calcareous ſulphat; and no change takes place, if the latter be very pure, and the ammoniac perfectly cauſtic. But if the water in which the calcareous ſulphat is diſſolved contains any ſalt with baſe of magneſia, or alumine, as the well water of Paris does, ammoniac will occaſion a precipitate. To ſucceed in the former experiment, calcareous ſpar muſt be diſſolved in the pure ſulphuric acid, and the calcareous ſulphat diſſolved in diſtilled water; cauſtic ammoniac poured on this ſolution, or which is ſtill better, the ammoniacal gas, occaſions no precipitate.

Carbonat of potaſh and calcareous ſulphat mutually decompoſe each other; the ſulphuric acid quitting the lime to unite with the fixed alkali, and forming carbonic acid, while the ſulphat of potaſh unites with the lime, and forms the ſalt known by the name of *chalk.*

Carbonat of ſoda is decompoſed in the ſame manner by this ſalt, ſulphat of ſoda being formed by the union of the ſulphuric acid with the mineral fixed alkali; at the ſame time that chalk is produced by the combination of the lime with the carbonic acid.

The carbonat of ammoniac likewiſe decompoſes calcareous ſulphat by double affinity; while the ſulphuric acid ſeizes the ammoniac, the lime combines with the carbonic acid, to which it has a ſtrong affinity, and forms chalk.

This decompoſition, whoſe cauſe is ſo well known ſince the diſcoveries of the celebrated Dr. Black, is ſo evident, that if a mixture of the ſolution of calcareous ſulphat with cauſtic ammoniac be left for ſome time expoſed to the air, it loſes its original tranſparency, and becomes remarkably cloudy at its ſurface, by reaſon of the carbonic acid precipitated from the atmoſphere, which cauſes a double affinity to take place; and the ſame phenomenon is produced by paſſing a few bubbles of this acid gas through the liquor. As the concrete volatile alkali, or carbonat of ammoniac was formerly thought to be the pure volatile alkali, Geoffroy, from the precipitation of calcareous ſulphat by this ſalt, concluded that the affinity of ammoniac is greater than that of lime to the ſulphuric acid.

Calcareous ſulphat is decompoſed by a great number of combuſtible matters, by the aſſiſtance of heat. The charcoal of vegetable ſubſtances deprives the ſulphuric acid of the oxygene, to which it has a greater affinity than ſulphur has. Carbonic acid is diſengaged in this decompoſition, and the ſulphur, ſeparated from the ſulphuric acid, unites to the lime, and forms the ſubſtance called *calcareous hepar;* but which we ſhall hereafter diſtinguiſh by the name of *ſulphure of lime.*

Varieties of calcareous ſulphat in a cryſtalline form, are carefully preſerved in cabinets of natural hiſtory. When calcined, it is uſed to caſt ſtatues, models, &c. Several elegant pieces of ornamental furniture are made of the gypſeous alabaſter, cut and poliſhed. The fine ſpecimens of Lagny are employed for this purpoſe.

Plaſter-ſtone is one of the moſt uſeful articles produced in the mineral kingdom. It conſiſts of a mixture of calcareous ſulphat and chalk; when it is expoſed to the action of heat, the calcareous ſulphat loſes its water of cryſtallization, and the chalk its acid: burned plaſter is therefore a mixture of lime and calcareous ſulphat deprived of water; conſequently, when water is poured on this ſubſtance, it is very rapidly abſorbed by the lime, and heat is produced. The fœtid ſmell which attends the extinction of plaſter, ariſes from a ſmall quantity of ſulphur formed by the ſulphuric acid, which is decompoſed by the carbonaceous animal or vegetable ſubſtances caſually exiſting in the plaſter-ſtone; the ſulphur diſſolved by the lime forms a kind of *ſulphure* from which the ſmell proceeds. When the lime has abſorbed a ſufficient quantity of water to form a paſte, the calcareous ſulphat ſeizes a portion of the fluid, and the whole maſs cryſtallizes ſuddenly, and at the ſame time becomes ſolid. The lime gradually dries, and together with the cryſtals of calcareous ſulphat forms the kind of mortar called plaſter. From this theory it is ſeen, why plaſter ought not to be burned beyond a certain point. If it be ſhort of this, the lime will not be ſufficiently deprived of cretaceous acid to unite well with water; if it exceed, the lime, together with the calcareous ſulphat, forms a kind of vitreous frit, incapable of uniting with water.

We may likewiſe obſerve that plaſter, by long expoſure to air, loſes its goodneſs by the lime becoming ſlaked, and that its original properties may be reſtored by a ſecond calcination. Laſtly, We may with equal facility account for the preſervation of this ſubſtance in dry and warm ſituations, and its deſtruction or ſcaling off in moiſt places. In the latter caſe, the calcareous ſulphat boing ſoluble in water, loſes by degrees its cryſtalline form and conſiſtence; and this ſolubility conſtitutes the chief difference between plaſter and mortar; the ſand in this laſt, which gives ſolidity, not being attacked by water. Plaſter is not, on this account, uſed in humid or moiſt places, or in any works near or under water, as reſervoirs, &c [f].

Species II. Calcareous Nitrat.

Calcareous nitrat, or the ſalt produced by the combination of the nitric acid with lime, is much leſs abundant than calcareous ſulphat or ſelenite. It is only found in ſuch places as afford the nitre with baſe of alkali. It is formed on the ſides of walls in places inhabited by animals, in putrefied animal matters, and in certain mineral waters; but as it is very ſoluble in water, and even deliqueſcent, it is diſſolved even almoſt as ſoon as formed. The ſame property is the cauſe why it is retained in large quantities in the mother-water of the ſaltpetre-makers.

When regularly cryſtallized, it has the form of a ſix-ſided priſm, conſiderably reſembling nitrat of potaſh, and terminated by dihedral pyramids. It is not often obtained in this regular form, but is moſt commonly in that of ſmall needles adhering together, whoſe form cannot be determined.

This ſalt has a bitter and diſagreeable taſte, in which reſpect it differs greatly from calcareous ſulphat; its taſte is rather cool, like nitrat of potaſh.

It eaſily melts by heat, and becomes ſolid on cooling; if it be carried into the dark, after being thus heated, it appears luminous, and in this ſtate conſtitutes the phoſphorus of Baldwin; it exhibits the ſame phenomenon when laid on a hot iron. On ignited coals it melts and detonates feebly, in proportion as it becomes dry. Calcareous nitrat kept hot for a long time loſes its acid, which is decompoſed. When this operation is performed in a retort, whoſe neck is plunged under an inverted veſſel filled with water, vital air is obtained, and towards the end ſome azotic gas. The reſidue conſiſts of lime united to a certain quantity of nitric acid, if the fire has been not continued for a ſufficient time, or ſufficiently intenſe; but a very powerful degree of heat will at laſt entirely decompoſe the nitric acid, and leave the baſe in the form of quick-lime. This decompoſition is abſolutely ſimilar to that which the acid experiences in the diſtillation of nitrat of potaſh, and has been explained in the hiſtory of that ſalt.

Calcareous nitrat quickly attracts the moiſture of the air, and for that reaſon it is neceſſary to keep the cryſtals of this ſalt in well cloſed veſſels, which muſt not be opened too frequently.

It is very ſoluble in water, two parts of cold, or leſs than one part of boiling water, being ſufficient to hold it in ſolution. To obtain it in a cryſtalline form, its ſolution muſt be evaporated nearly to the conſiſtence of ſyrup, and expoſed in a cool place. The cryſtals formed by this means are very long priſms, commonly diverging from one centre. When a ſolution of calcareous nitrat, leſs evaporated than the foregoing, is expoſed to a dry and hot air, priſms are formed in proceſs of time, which are more regular, and are ſimilar to thoſe deſcribed at the beginning of this article.

Sand and clay decompoſe calcareous nitrat, and ſeparate the acid.

Barytes, according to Bergman, decompoſes this ſalt as it does calcareous ſulphat; but magneſia produces no ſenſible alteration in it. Morveau has obſerved that lime-water, poured into a ſolution of calcareous nitrat, occaſions a precipitate. He attributes it to the phlogiſton of quick-lime, and he thinks that this laſt has a ſtronger affinity with the nitrous acid than the lime to which it is united has, and which he ſuppoſes to have been already robbed of its phlogiſton by the acid. It is unfortunate that this chemiſt did not examine the precipitate, which might probably have afforded ſome explanation of this ſingular experiment. Baumé had before obſerved, that a ſolution of calcareous ſpar in the nitrous acid is precipitated by lime-water; but he attributed this phenomenon to a ſmall quantity of argillaceous earth contained in the ſpar. This effect depends either on a ſmall quantity of magneſia, or the avidity of the calcareous nitre for water, which it takes from the lime.

Fixed alkalis ſeize the nitric acid of calcareous nitrat, and precipitate the lime. Very pure ammoniac does not decompoſe this ſalt, nor any other with a calcareous baſe.

The ſulphuric acid diſengages the nitric acid with effervescence, which may be obtained in the ſame manner as from common nitre. Sulphuric acid poured on a ſolution of calcareous nitrat immediately produces a precipitate of ſulphat of lime, and the nitric acid remains diſengaged in the liquid. The action of other acids on this ſalt is not known.

Calcareous nitrat decompoſes the alkaline ſulphuric neutral ſalts; ſulphat of lime, and nitrat of potaſh and ſoda, being formed. The ſulphat of ammoniac is likewiſe decompoſed, and nitrat of ammoniac, together with ſulphat of lime, are produced: the latter, which, being ſcarcely ſoluble, is precipitated at the inſtant of mixture, leaves no doubt with regard to the nature of theſe double decompoſitions.

Carbonat of potaſh and calcareous nitrat mutually decompoſe each other, nitrat of potaſh remaining in the ſolution, and chalk being precipitated.

Carbonat of ſoda and calcareous nitrat in the ſame manner afford nitrat of ſoda in ſolution, and a precipitate of calcareous carbonat or chalk.

Sulphat of lime does not produce any change in calcareous nitrat; but when theſe two ſalts are diſſolved in the ſame water, they may be eaſily ſeparated; for the firſt being very ſparingly ſoluble, and the latter eminently ſo, the ſulphat of lime is precipitated by evaporation, and the calcareous nitrat does not cryſtallize till great part of the fluid has been driven off, and the reſidue ſet to cool.

Calcareous nitrat is not applied to any uſe; it might be employed in medicine as a very active ſolvent, and ſome chemical phyſicians affirm, that its application has been attended with ſucceſs [g].

Species III. Calcareous Muriat.

The calcareous muriat, formed by the combination of the muriatic acid and lime, and which was formerly very improperly named *fixed ſal ammoniac, oil of lime,* &c. is abundantly found in all places that abound with muriat of ſoda, and eſpecially in the waters of the ſea; where it produces that acrid and bitter taſte, which formerly cauſed it to be ſuppoſed to contain bitumen. It is never pure in the ſea, but always mixed with muriat of magneſia: if it be deſired in a ſtate of great purity, muriatic acid muſt be directly combined to ſaturation with lime.

Calcareous muriat, in its dry and ſolid ſtate, has the form of four-ſided priſms, ſtriated and terminated with very acute pyramids. It has a very diſagreeable bitter ſaline taſte. When expoſed to the action of a mild heat it is liquified by means of its water of cryſtallization, and becomes ſolid again when cold; a ſtronger heat ſcarcely alters it. Mr. Baumé has obſerved, that it does not part with its acid: it becomes luminous on a red hot ſhovel, for which reaſon it is called *Homberg's phoſphorus.*

The calcareous muriat which remains in the retort after the decompoſition of muriat of ammoniac by lime, and is called *fixed ſal ammoniac*, melts into a kind of frit of a light ſlate grey, and does not afford muriatic acid, though the heat be raiſed ſo as even to vitrify the ſurface of the retort. This frit gives fire with ſteel, and when rubbed in the dark with the ſteel, it gives a phoſphoric light.

It muſt be obſerved, that this ſaline reſidue commonly contains a larger portion of lime than is neceſſary for the complete ſaturation of the muriatic acid; becauſe more lime is uſually employed than is neceſſary to decompoſe the muriat of ammoniac. It is doubtleſs from this ſuperabundant lime, that the reſidue acquires the property of affording a hard vitreous frit; which however becomes moiſt in proceſs of time when expoſed to the air. The calcareous muriat, without exceſs of lime, never becomes ſo hard by the action of fire as this reſidue, neither has it the ſame phoſphoric quality.

Pure calcareous muriat expoſed to the air attracts humidity, and liquifies. The cryſtalline form cannot, therefore, be preſerved, but in well cloſed veſſels.

This ſalt is very ſoluble in water; one part and a half of cold, or leſs than an equal part of hot water, being ſufficient to diſſolve it. When by evaporation the liquid is brought nearly to the conſiſtence of ſyrup, and afterwards ſuffered to cool gradually, priſmatic tetrahedral cryſtals are obtained ſeveral inches in length, diſpoſed in radii iſſuing from a common centre; a figure which we may obſerve is common to moſt calareous ſalts. If the liquor be too far evaporated, or if it be cooled too quickly, the ſaline maſs is irregularly formed, with the appearance of needles at its ſurface.

A ſolution of calcareous muriat evaporated till it exhibits forty-five degrees of Baumé's areometer, and expoſed in a bottle to the cold, affords very regular priſms, frequently of conſiderable magnitude. Sometimes, when the cryſtallization has not taken place, and the bottle is agitated, the maſs ſuddenly becomes ſolid throughout, much heat being at the ſame time diſengaged.

Barytes decompoſes calcareous muriat, by its greater affinity to the acid, according to the experiment of Bergman. Lime and magneſia do not change it.

Fixed alkalis precipitate lime: if the two fluids be concentrated, the lime abſorbs the ſmall quantity of water they contain, and immediately forms a jelly, which ſoon becomes ſolid. This experiment has been called *miraculum chemicum*, becauſe it exhibits a combination of two fluids ſuddenly become ſolid. It does not, however, ſucceed well but with carbonats of potaſh and ſoda; the pure alkalis precipitating the lime in too divided a ſtate.

Very pure ammoniac does not decompoſe calcareous muriat, becauſe its affinity is leſs than that of lime to the muriatic acid. This order of affinity is likewiſe proved from the complete decompoſition of muriat of ammoniac by the ſame ſalino-terreſtrial ſubſtances.

The ſulphuric and nitric acids diſengage the muriatic acid from this ſalt with effervеſcence, and the acid may be obtained by diſtillation in the ſame manner as from muriat of ſoda. When the nitric acid is uſed, nitro-muriatic acid, or *aqua regia*, is produced, on account of the volatility of both acids.

Calcareous muriat decompoſes the ſulphats of potaſh and ſoda. It is eaſy to aſcertain this fact, by mixing ſolutions of theſe ſalts together. A precipitate is immediately formed, which is found to be ſulphat of lime. The fluid contains either muriat of ſoda or potaſh, which may be obtained by evaporation, and is diſtinguiſhable by the taſte.

The carbonats of potaſh and ſoda likewiſe decompoſe the calcareous muriat. In theſe mixtures the decompoſitions are made by double affinity: the muriatic acid of the latter ſalt ſeizes the potaſh or ſoda, with which it forms the muriat of potaſh or ſoda, which remains diſſolved in the liquor; while the carbonic acid quits the alkali, and uniting with the lime, forms chalk, or the carbonat of lime which is precipitated.

If the carbonat of potaſh or ſoda be diſſolved in a ſmall quantity of water, and the ſolution of muriat of lime be alſo made very ſtrong, the mixture becomes thick and gelatinous. It afterwards hardens like a factitious ſtone, when the ingredients are accurately proportioned to each other. The chemiſts who firſt diſcovered this mixture, called it the *Chemical Miracle.*

The carbonat of ammoniac decompoſes calcareous muriat by double affinity, in the ſame manner as has been ſhown with reſpect to calcareous ſulphat and nitrat. The ammoniac unites with the muriatic acid, and forms muriat of ammoniac, which remains diſſolved in the liquor, while the carbonic acid forms a precipitate of chalk by combining with the lime[h].

When the calcareous muriat is diſſolved in water together with calcareous nitrat, it is difficult to ſeparate them; becauſe the law of cryſtallization is the ſame in both; but if ſulphat of lime exiſts in the ſolution inſtead of one of the two ſalts, the ſeparation will be eaſily made, becauſe this laſt cryſtallizes by evaporation, and the calcareous muriat cryſtallizes by cooling: as theſe ſalts are frequently found diſſolved in the ſame acid, it is of conſequence to attend to theſe properties.

Calcareous muriat is of no uſe. As it exiſts in conſiderable quantities in the *ſel de gabelle* which is recommended as a purge in ſcrophulous diſorders, it may be ſuſpected that a part of its properties depend on the latter ſalt. We think it neceſſary to add, that the ſtrong taſte and great ſolubility of calcareous muriat promiſe very uſeful effects in diſorders where a ſolvent is wanting. It is much to be wiſhed that phyſicians were acquainted with the properties, and availed themſelves of the uſe of this ſalt, in thoſe numerous caſes where the uſual ſolvents are frequently ineffectual, and more eſpecially in thoſe caſes wherein mercurial remedies cannot be uſed. I have collected together all that experience has already taught us concerning the virtues of this ſaline ſolvent, in a memoir, inſerted among thoſe of the Royal Society of Medicine, for the years 1782 and 1783.

Species IV. Calcareous Borat.

The combination of the *ſedative* or boracic acid with lime may be diſtinguiſhed by this appellation. This ſalt has not been examined, though it is certain that the boracic acid is capable of uniting with lime, becauſe the latter decompoſes borat of ſoda, as we have obſerved. The chemiſts of the academy of Dijon have obſerved, that concrete boracic acid, heated with ſlaked lime, afforded a ſubſtance whoſe parts adhered weakly to each other, and not at all to the crucible. This matter, when thrown into water, did not exhibit the ſame phenomena as lime, which ſhows that a true combination took place. Baumé affirms, that having ſaturated lime-water with *ſedative ſalt*, and expoſed the ſolution to ſpontaneous evaporation, no cryſtals were obtained, but yellowiſh pellicles, having a ſlight taſte of boracic acid. Laſtly, The academicians of Dijon digeſted on a ſand bath a ſaturated ſolution of this acid with ſlaked lime. The filtrated liquid afforded a plentiful white precipitate, on the addition of fixed alkali. Theſe experiments, indeed, prove that lime is ſoluble in the acid of borax, but they ſhow nothing concerning the properties of the neutral ſalt reſulting from their combination.

Species V. Fluor Spar, or Calcareous Fluat.

This ſpecies of ſalt is a combination of the fluoric acid with lime, and abounds in nature; it is more eſpecially found in the neighbourhood of mines, whoſe exiſtence it indicates. It has been hitherto regarded as a ſtony matter, from its inſipidity, hardneſs, and inſolubility. It is called *ſpar*, becauſe it has the ſparry form and fracture; *fluor*, or *fuſible*, becauſe it melts very readily, and is ſucceſsfully employed in mineral operations; and *vitreous*, becauſe it has the appearance of glaſs, and may be fuſed into glaſs of no contemptible appearance; *cubic*, becauſe it always has that form; and, laſtly, *phoſphoric*, becauſe, when heated and carried into the dark, it appears luminous. Before the diſcovery of Scheele, the vitreous ſpar, though well diſtinguiſhed from all other mineral matters by workmen, on account of its fuſibility, was confounded by naturaliſts, either with gypſums, calcareous ſpars, or ponderous ſpars, which have likewiſe been called *fuſible*. The celebrated Margraaf nevertheleſs diſtinguiſhed this ſalt from the ponderous ſpar, by adopting the name of fuſible vitreous ſpar for the firſt, and fuſible phoſphoric ſpar for the ſecond. It is to this chemiſt that we are indebted for the firſt diſcoveries relating to the properties of calcareous fluat.

This ſalt is commonly cryſtallized in cubes, of various colours, very regular, of an icy or vitreous tranſparency; its fracture is ſparry, and it is eaſily broken. It often ſerves as the matrix or bed of ores. It is ſometimes found in irregular opaque maſſes; its weight is more conſiderable than that of any ſaline matters we have yet ſpoken of; it is often clouded, veined, ſpotted, and frequently tinged throughout with green, violet, red, roſe colour, &c. Ten principal varieties of this ſubſtance may be diſtinguiſhed.

Varieties.—1. Calcareous fluat, or cubic vitreous ſpar, tranſparent and colourleſs.

2. Calcareous fluat, or cubic vitreous ſpar, opaque white.

3. Calcareous fluat, or cubic vitreous ſpar, yellow: falſe topaz.

4. Calcareous fluat, or cubic vitreous ſpar, reddiſh: falſe ruby.

5. Calcareous fluat, or cubic vitreous ſpar, pale green: falſe aqua-marine.

6. Calcareous fluat, or cubic vitreous ſpar, green: falſe emerald.

7. Calcareous fluat, or cubic vitreous ſpar, violet: falſe amethyſt.

8. Calcareous fluat, or octahedral vitreous ſpar, with truncated pyramids.

I am in poſſeſſion of a cryſtal of this kind, which is ſemi-tranſparent, and rather blackiſh.

9. Calcareous fluat, or vitreous ſpar, in irrregular maſſes.

It is almoſt always of a clear green or violet. It forms the gangue of ſeveral ores.

10. Calcareous fluat, or vitreous ſpar, in layers of different thickneſs, and of various colours.

Theſe different varieties of calcareous fluat, conſiſt, for the moſt part, of one and the ſame ſaline ſubſtance; that is to ſay, the combination of the fluoric acid with lime; the natural ſpecimens, however, are uſually found by analyſis to contain ſeveral foreign matters, as quartz, clay, and iron, as almoſt all natural products do. England abounds in calcareous fluat.

This earthy ſalt, expoſed to a gentle heat, emits a very evident phoſphoric light; but if it be heated to redneſs, it entirely loſes this property; and if the ſpar be of a green or violet colour, it becomes white and friable: when ſuddenly heated, it decrepitates almoſt as ſtrongly as muriat of ſoda. When powder of fluat of lime is thrown on a hot iron, a bluiſh or violet light is perceived, which quickly vaniſhes, and cannot be produced again by the ſame ſpar.

A ſtrong heat fuſes vitreous ſpar into an uniform tranſparent glaſs, adhering to the crucible. Calcareous fluat fuſes the one fourth of its weight of quartz, and is for that reaſon employed as a flux in ſmelting.

Calcareous fluat is not altered in the air, nor ſoluble in water. Pure fixed alkalis do not decompoſe it, becauſe, according to Bergman, lime has a ſtronger affinity than thoſe ſalts to its acid.

Concentrated ſulphuric acid diſengages the fluoric acid, and is commonly the medium uſed for that purpoſe. One part of calcareous fluat, in powder, is put into a retort, with three parts of ſulphuric acid; the mixture gradually becomes hot; an efferveſcence takes place; and vapours of fluoric acid are diſengaged. This diſtillation commences without the external application of heat; and a white ſubſtance, reſembling an efflореſcence, ſublimes into the receiver. Heat being then applied, the concentrated fluoric acid comes over, covered with a thick earthy pellicle, ſimilar to the white efflorefcence we have mentioned; while the acid falls drop by drop into the water in the receiver. This acid may be obtained in the form of gas, while the neck of the retort is plunged beneath an inverted veſſel of mercury. The aeriform acid is tranſparent, and does not depoſit the earth to which it is united, until it is brought in contact with the water. Hence it may be conceived why the liquid fluoric acid depoſits ſtony incruſtations in the receiver; for it cannot hold them in ſolution when it comes in contact with the water. We have before obſerved, that this earth, which is of a ſilicious nature, is taken up by the corroſion of the glaſs veſſel, and is not produced by the combination of the acid with water, as Scheele originally thought. When the diſtillation is finiſhed, the reſidue is obſerved to be hard, white, or reddiſh, and laminated, and the retort is very ſenſibly corroded. This obſervation did not eſcape Margraaf. When the nature of the reſidue is examined by different methods, it is found to conſiſt of calcareous ſulphat mixed with a ſmall quantity of ſilex, frequently alumine, and a little magneſia. Thoſe two laſt ſubſtances, as well as iron, ſeem to be only accidental in calcareous fluat. The cruſt depoſited by the fluoric acid, is of a ſilicious nature, is neither fuſible nor ſoluble in acids, and forms a white and durable glaſs with fixed alkalis. Theſe facts ſhow, that it is impoſſible to diſtil a large quantity of this acid at once. I have ſeveral times attempted to decompoſe a pound of calcareous fluat, but never found the retort capable of withſtanding the corroſive acid.

The nitric acid decompoſes calcareous fluat, but with very different phenomena from thoſe which attend the ſulphuric acid, no cruſt being obſerved in this operation, according to Boulanger: this experiment has not been repeated and examined.

The muriatic acid likewiſe ſeparates the fluoric, according to Scheele; but he has not deſcribed the phenomena which attend this decompoſition.

The action of moſt neutral ſalts on calcareous fluat is not known; the carbonats of potaſh and ſoda decompoſe it by double affinity, which the pure alkalis cannot effect. One part of this fluat being fuſed with four parts of carbonat of potaſh, and poured hot into water, a precipitate of chalk, formed by the carbonic acid united to the lime of the calcareous fluat, is obtained; and the fluid holds in ſolution fluat of potaſh, which may be obtained, by evaporation, in the form of a jelly. When the experiment is repeated with carbonat of ſoda, chalk and fluat of ſoda are in like manner obtained.

Calcareous fluat is of no uſe excepting in ſome mineral countries, where it is uſed as a very good flux. It might be applied to the ſame purpoſe in aſſays.

Species VI. Carbonat of Lime or Chalk; Calcareous Matters in general.

Calcareous ſpar, marble, chalk, and every calcareous ſubſtance, is a neutral ſalt, formed by the union of carbonic acid with lime. It is therefore termed *carbonat of lime*, or *calcareous carbonat*. This ſubſtance has been arranged among ſtones by naturaliſts, becauſe they did not perceive that it has any ſaline properties. We ſhall, however, find that it has a kind of taſte, is ſoluble in water, and in its analyſis affords a large quantity of carbonic acid, and the ſalino-terreſtrial ſubſtance already deſcribed under the name of lime. As calcareous ſpar is the laſt modification of a ſubſtance which exiſts in a great variety of forms, and paſſes through many ſtates before it is regularly cryſtallized, it is neceſſary to conſider calcareous or cretaceous ſubſtances in general *.

No part of natural hiſtory exhibits a more extended field for the imagination to trace, or a more complete ſeries of well-eſtabliſhed facts, than that which relates to calcareous bodies. Long continued obſervation, which has in no inſtance failed, together with the facts which ſhow the ſucceſſive operations of nature in this reſpect, have proved, that the bed of the ocean is the great laboratory in which theſe matters are continually formed. Among the great number of animals which inhabit thoſe immenſe maſſes of water, there are ſeveral claſſes whoſe individuals, infinite in number, ſeem deſtined to add to the maſs of our globe: ſuch are the ſhell-fiſh, madrepores, and lithopites, whoſe ſolid parts, examined by chemical analyſis ſome time after they have ceaſed to live, exhibit all the characters of calcareous ſubſtances. It is the baſe of this kind of marine ſkeletons which produces, by their ſucceſſive aggregation, mountains entirely formed of theſe matters. Though the cryſtallization of calcareous ſpar is very far from reſembling the natural ſoft ſtate of theſe animals when living; and though it is difficult at firſt to eſtimate the aſtoniſhing difference between the ſoft and pulpy ſubſtance of the living animal, and the hardneſs of the ſtony ſubſtances which are formed in proceſs of time, and calculated to give ſolidity to the largeſt edifices, it is nevertheleſs poſſible to form an idea of the gradations through which the one muſt paſs before it aſſumes the ſtate and properties of the other. The following ſketch will exhibit theſe gradations, from the time of the action of the animal organization, to that of the regular depoſition, by which tranſpa-

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* The ſubſtances uſually called *calcareous* in natural hiſtory, ought, in my opinion, to be called *cretaceous*; this laſt term denoting the ſaline neutral combination formed by the union of lime and carbonic acid; that is to ſay, chalk, *creta*. The ſecond property belongs to the lime, *calx*, which forms the baſe of this ſalt. The expreſſion *calcareous earth*, or *calcareous matter*, ought therefore to be appropriated to quick-lime; and the term *cretaceous*, or *chalky matter*, will diſtinguiſh the combination of lime with the acid of chalk; but it is not to be expected that theſe two expreſſions, which have always been ſynonymous, ſhould be ſpeedily adopted, though they certainly ought to be applied to different ſubſtances, and ſeem calculated to enrich our chemical language.

rent and cryſtallized carbonat of lime or *calcareous ſpar* is ſlowly formed.

The waters in the ſea, librating according to laws yet unknown to us, are inſenſibly diſplaced, and change their bed; they quit one coaſt, which gradually encroaches on the ſea, while they advance on another, whoſe extent is diminiſhed in the ſame proportion: this fact is proved in Buffon's learned Theory of the Earth. In proportion as the waters quit one part of their bed, they leave the bottom uncovered, on which their various motions, ſo well deſcribed by this celebrated writer, have formed beds, by the ſucceſſive depoſitions of ſolid matter, or the ſkeletons of marine animals. Theſe ſtrata are almoſt entirely filled with ſhells, whoſe animal gluten has been deſtroyed by putrefaction, and which, having loſt their colour, poliſh, and conſiſtence, are become friable and earthy, and have paſſed into the ſtate of foſſils. Hence the production of earths and ſtones containing ſhells.

Theſe ſtones, by the action of the rain waters, gradually loſe the organic form, become more and more friable, and form a ſubſtance of a texture ſcarcely conſiſtent, which is called *chalk*. When a ſtone, compoſed of ſhells, has acquired ſufficient hardneſs to be capable of poliſh, and when the ſhells have become variouſly coloured, it then conſtitutes the *lumachello*. If the traces of organization are entirely deſtroyed, and the ſtone be hard and ſuſceptible of poliſh, it is diſtinguiſhed by the name of *marble*. Water, impregnated with chalk, depoſits it on ſuch bodies as it paſſes over, and forms *incruſtations*. When it filters through the roofs of ſubterraneous cavities, it forms white opaque depoſitions, compoſed of concentric layers, whoſe figure on the whole is conical. Theſe *ſtalactites*, if united together in large maſſes, and perfectly filling up the caverns, remain a long time in the earth; they acquire conſiderable hardneſs, and produce *alabaſter*. *Laſtly*, When water, holding in ſolution chalk in the moſt attenuated ſtate, ſlowly penetrates into the cavities of rocks, it will depoſit this ſubſtance, particle by particle, as it were; and theſe ſmall bodies, being applied to each other by the ſurfaces beſt adapted to unite, will take a ſymetric and regular arrangement, and form hard tranſparent cryſtals, ſimilar to thoſe of ſaline ſubſtances: theſe are *calcareous ſpars*. This ſtate is the laſt, or moſt remote from its animal origin, in which chalk is found, and in which it has the greateſt reſemblance to a true ſalt.

Theſe various and numerous tranſitions of the cretaceous ſubſtance (the conſideration of which affords the greateſt inſtruction to the naturaliſt, concerning the antiquity of the globe, its alterations, and the extent of the animal kingdom, whoſe ſubjects conſtitute a vaſt portion of its ſurface and external ſtrata), preſent only to the eyes of the chemiſt one ſingle and identical neutral ſalt, formed of lime and carbonic acid. We ſhall proceed to conſider the ſubject in both points of view.

§ I. *The Natural Hiſtory of Calcareous Subſtances*[*].

Before we enter into a particular account of calcareous matters, it will be proper to take a general view of their diſpoſition in the earth. Theſe ſubſtances form beds of greater or leſs extent, horizontal or inclined, which appear manifeſtly to have been formed by the action of waters. Theſe beds compoſe whole mountains, hills, &c. and form a great part of the external covering of the globe. They prove that the waters of the ſea have formerly covered the earth, and have depoſited an immenſe quantity of the exuviæ of their inhabitants. The rain waters, filtering through theſe calcareous maſſes, carry a portion along with them, which they diſtribute at greater depths, in ſubterraneous cavities, under the different forms we ſhall proceed to examine.

Their general characters, as given by naturaliſts, are highly uſeful to diſtinguiſh them, and are founded on two remarkable properties: their not giving fire with ſteel, and their effervefcence with acids. As it is evident, from what has been already ſaid, that the form of calcareous matters is conſiderably varied, it is indiſpenſably neceſſary to divide them into ſeveral genera. We admit ſix[†].

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[*] Though we have already, in the Hiſtory of Earths and Stones, exhibited the methodical diviſions of calcareous ſubſtances, uſually diſtributed in this claſs by naturaliſts, yet we think it proper, in this ſection, to exhibit them under another arrangement, which refers to conſiderations different from thoſe by which the compilers of Nomenclatures in general are guided. *Note of the Author.*

[†] It may perhaps be thought ſtrange, that a diviſion of genera ſhould be made in the hiſtory of one ſpecies of ſalt; but it muſt be obſerved, that theſe genera relate only to natural hiſtory, and that in fact they are referable to the ſpecies of neutral ſalt, whoſe chemical properties we are examining. *Note of the Author.*

GENUS I. Earths and Stones containing Shells.

Theſe ſubſtances have been arranged among ſtones, becauſe they have no apparent degree of taſte or ſolubility; but their analyſis ſhows that they are truly ſaline, as well as the other genera which follow. They are known by the organic form of the ſhells they contain; theſe are often entire, ſo that the ſtone itſelf is merely a maſs of ſhells: the original colours partly remain in ſome ſpecimens. Among the animals whoſe exuviæ exiſt in this ſtate, ſeveral are obſerved which are extinct, or no longer found living in the ſea; ſuch as many ſpecies of *cornua-ammonis*, and *nautili*. On the other hand, foſſil ſhells are found in France, and other parts of Europe, the living individuals of which are found only in America. Some naturaliſts have made very extenſive diviſions of foſſil ſhells; but as they reſemble thoſe of the living animals, we ſhall ſpeak of them in another part of our work.

There likewiſe exiſt among the foſſil remains of marine animals, bodies whoſe form and organization cannot, in any reſpect, be referred to any known inhabitant of the ſea. Though we do not yet poſſeſs any complete treatiſe upon foſſil animals, and though this part of natural hiſtory has not been treated with the ſame care and preciſion as mineralogy, the deſcription of a conſiderable number of theſe bodies is ſufficient to prove, that animals have exiſted in the ſea whoſe ſpecies have been deſtroyed. When the foſſil calcareous ſubſtances manifeſtly appear to have belonged to known animals, they are then diſtinguiſhed by a name relative to their origin, and commonly formed out of the claſs of animals to which they belong, adding another name, which denotes their ſtony nature; ſuch as madreporites, &c. But it muſt be obſerved, that the bones of men, quadrupeds, birds, and fiſhes, which are dug out of the earth, and are known by the name of foſſils, are not of a calcareous nature, but preſerve the nature of calcareous phoſphat: ſo that the ornitholithes, the ichthyolithes, &c. muſt not be arranged among cretaceous ſubſtances.

There are many foſſil organic ſubſtances, whoſe origin is not known; theſe are named from their form, ſuch are the lapides *Judaici*, which ſome think are the ſpiculæ of ſea hedge-hogs; the lapides *numiſmales*, reſembling pieces of money, and which appear to be ſmall cornua-ammonis applied upon each other; *foſſil-bezoar*, a kind of round maſs or concretion in concentric layers; the *ludus Helmontii*, whoſe ſpaces ſeem to have been formed by the drying and ſhrinking of an earthy ſubſtance, which afterwards became filled with calcareous earth. The *trochites*, *entrochi*, and *aſtroites*, which are produced from a zoophite named *ſea-palm;* the *piſolites*, *oolites*, or *meconites*, which are thought to be petrified fiſhes eggs, or inſects, but whoſe true origin is unknown.

As all petrified ſubſtances, whatever animals they may have belonged to, have been referred to this genus of ſtones, which are truly calcareous; natural hiſtory likewiſe enumerates in this place *gammarolites*, *cancrites*, *entomolites*, *amphibiolites*, *zoolites*, *antropolites :* But ſince the new diſcoveries concerning the nature of bones, theſe matters can no longer be referred to cretaceous ſubſtances, as we have already pointed out. The ſame obſervation may be made reſpecting the *gloſſopetræ*, or *petrified ſharks teeth*, *ivory* or *foſſil unicorn*, which is produced from elephants teeth; *turquoiſe*, or *bones coloured green and blue; toad-ſtones;* grey or yellow and hollow ſtones, which, according to Mr. Juſſieu, are the upper parts of the grinders of the Brazilian fiſh called *Grondeur;* and the *ſerpents eyes*, which, according to that naturaliſt, are the inciſive teeth of the ſame fiſh.

After this previous explanation, the preſent genus may be reduced to two ſpecies, containing every poſſible variety.

Species 1. Entire ſhells or foſſils.

Theſe are diſtinguiſhed by different circumſtances of colour, brilliancy, hardneſs, &c. In this ſpecies are comprehended madrepores, and all the habitations of polypi in the foſſil ſtate.

2. Falun, or cron.

Shells broken, and in the form of earth. The ſoil of Tourain, and ſeveral other provinces of France is entirely of this nature. It is uſed as an excellent manure.

GENUS II. Calcareous Earths and Stones.

They are formed out of the ſubſtances of the firſt genus worn down and depoſited by waters. They are found diſpoſed in beds or ſtrata within the earth. We ſhall follow Daubenton in the diſtinction of the different kinds.

Species 1. Compact calcareous earth; *chalk*

Its colour and grain are various; it is employed for many domeſtic purpoſes.

2. Spongy calcareous earth; *ſtone-marrow.*

3. Calcareous earth in powder; *foſſil flour.*

4. Calcareous earth of the conſiſtence of cream; *lac-lunæ.*

5. Soft calcareous earth; *tufa.*

It hardens and becomes white by drying.

6. Calcareous earth in large grains.

The earth of Arcueil is an inſtance of this; it contains ſhells broken to pieces.

7. Fine grained calcareous earth.

The thunder-ſtone is a variety of this.

Without entering into uſeleſs details, it may eaſily be imagined that the hardneſs, and the ſeveral uſes to which theſe earths and ſtones are applied, afford names to a great number of varieties. In general they ſerve to make lime, and for the conſtruction of edifices, &c. &c.

Genus III. Marble.

Marbles differ from calcareous ſtones properly ſo called, in being rather harder; like them they effervefce with acids, have a granulated fracture, and do not give fire with ſteel; but their grain is much finer and cloſer, their colours more brilliant, and they take a better poliſh. Every one is acquainted with the uſe of marble in ſculpture, architecture, &c. It is likewiſe uſed in ſome countries to make lime.

Species 1. Lumachello.

This name is given by the Italians to marble compoſed of agglutinated ſhells.

2. Breccias.

This marble is compoſed of ſmall round maſſes bedded in a cement of the ſame nature.

3. Marble properly ſo called.

Neither the ſhells nor the lumachellos, nor the round maſſes of the breccias are found in this; its ſpots are irregular, and it is often veined. Daubenton arranges marbles according to the number and combination of their colours, and includes the lumachellos and the breccias under the ſame denomination.

1. Marble of ſix colours; for example, white, grey, green yellow, red, and black. Marble from Wirtemberg.

2. Marble of two colours; for example, white and grey. Marble from Carrara.

3 Marble of three colours; for example, grey, yellow, and black. Lumachello.

4. Marble of four colours; for example, white, grey, yellow, and red. Brocatello of Spain.

5. Marble of five colours; for example, white, grey, yellow, red, and black. Breccia of Old Caſtile.

Species 4. Figured marble.

It repreſents ruins, as in the marble of Florence; or plants, as in the Heſſian marble.

It muſt be obſerved that the colours of marble depend almoſt always on iron interpoſed between its grains. This ſtone, though ſuſceptible of a good poliſh, is very porous. It is well known how eaſily it is ſtained; and on this property is founded the art of drawing coloured flowers on marble.

Marble is often mixed with fragments of hard ſtone, ſuch as quartz, or ſilex, in which caſe it gives fire with ſteel at that part. I have frequently obſerved this character in ſeveral ſpecies of black marble.

GENUS IV. Concretions.

Concretions are formed irregularly by a depoſition of calcareous matter by water on the ſurfaces of bodies. They are not diſpoſed in large beds, but by fragments in maſſes, at firſt ſeparate, which gradually growing larger, join, and become confounded together.

Species 1. Incruſtations.

Waters loaded with chalk depoſit it on the ſurface of all bodies over which they flow. Incruſtations may therefore have every poſſible form, according to the ſubſtance which has ſerved as a nucleus. Such are thoſe ſpecimens from the waters of Arcueil; ſuch likewiſe is Oſteocolla, &c.

2. Stalactites.

They are formed ſlowly, and by concentric layers depoſited by waters at the vaults of caverns, &c. They vary in magnitude, tranſparency, grain, colour, and form; they are in general pyramidical and hollow. The *flos-ferri* is the pureſt of all. When they are adherent to the ſides of ſubterraneous cavities they are called *congelations;* when they ſtand on the floor of the cavern, they are denominated *ſtalagmites.*

3. Alabaſter.

Alabaſter appears to be formed by the pureſt ſtalactites, after remaining long in the earth; it is not ſo hard as marble, and when it is poliſhed, its ſurface appears greaſy and oily; it is manifeſtly compoſed of layers which have different directions; it has always an impefect tranſparency, which diſtinguiſhes it from marbles, but it is never ſo clear as ſpars. It is formed into vaſes and ſtatues; many varieties of this ſubſtance may be diſtinguiſhed.

Varieties.—1. Oriental alabaſter.

It is the moſt tranſparent and the hardeſt.

2. Occidental alabaſter.

Leſs beautiful and pure than the foregoing.

3. Alabaſter ſpotted with different colours.

4. Wavy alabaſter.

It is likewiſe called alabaſter of agate.

5. Alabaſter repreſenting figures of herbs.

GENUS V. Calcareous Spar.

Calcareous ſpar differs from the four preceding genera by its form, which is commonly regular, and eſpecially by its fracture. It conſiſts of laminæ applied on each other, as evidently appears from its fracture; it crumbles when ſtruck with a ſteel.

Species 1. Opaque calcareous ſpar.

It is white, or variouſly coloured, and uſually in the form of rhomboidal plates.

2. Tranſparent rhomboidal calcareous ſpar; Iceland cryſtal.

It doubles objects. This is often an artificial fragment.

3. Lenticular calcareous ſpar.

Romé de Lille is of opinion that this is a variety of the hexahedral priſmatic ſpar, terminated by two obtuſe and triangular pyramids, but it is merely the preceding variety rounded at its ſolid angles.

4. Priſmatic calcareous ſpar, without pyramids.

Theſe are truncated hexahedral priſms, whoſe faces are either equal or unequal, and whoſe angles are ſometimes truncated in ſuch a manner as to form twelve-ſided priſms. It conſequently has three varieties.

5. Calcareous ſpar in priſms, terminated by two pyramids.

There is a conſiderable number of varieties of this ſpar. Some are hexahedral priſms, terminated by hexahedral pyramids, either entire or truncated. Others preſent trihedral pyramids, either entire or truncated, or with dihedral ſummits, at the extremity of the ſame hexahedral priſms. Laſtly, There are quadrangular priſms terminated by dihedral ſummits. The regular cryſtals have 18 trapezoid faces.

6. Pyramidal calcareous ſpar.

This is compoſed of one or two pyramids united without an intermediate priſm; the hexahedral or triangular form of theſe pyramids, the inequality of their faces, and the truncature of their angles, eſtabliſh a great number of varieties *.

7. Dodecahedral calcareous ſpar.

8. Calcareous ſpar in ſtriæ.

This is an aggregate of long priſms adhering ſide-ways, which do not preſent any determinate or regular form. The ſwine-ſtone of the Swedes belongs to this ſpecies.

This ſpar, which in its figure reſembles a kind of garnet or marcaſite, appears to be compoſed of two pentagonal pyramids, truncated and united at their baſe.

This variety is formed by 12 pentagonal faces inverſely ſtriated; when ſmall, it is named ſpar *en tête de clous*.

§ II. *Concerning the Chemical Properties of Calcareous Carbonat.*

As the chemical properties depend on the combination or principles of bodies, it is neceſſary to give them names expreſſive of their nature; from this conſideration, the ſeveral calcareous ſubſtances we have treated of muſt be chemically treated of under the denomination of calcareous carbonat. It is upon the moſt tranſparent calcareous ſpar, or pure white marble, that the experiments muſt be made, which eſtabliſh the properties of this earthy ſubſtance.

In order to analyſe calcareous carbonat, its aggregation muſt be firſt deſtroyed by reducing it to powder. In this form it is white and opaque, and has no ſenſible taſte, though it ſeems to contract or harden the fibres of the tongue and palate, when kept for ſome time in the mouth.

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* An idea of the varieties of form diſtinguiſhable in ſpars, and of the great number of ſpecies thence reſulting, may be had by conſulting the Engliſh work of Dr. Hill, entitled the Hiſtory of Foſſils, &c. London 1748. Romé de Lille has given an extract in the firſt edition of his Cryſtallography, page 131, et ſeq. page 191, et ſeq. relative to calcareous ſpar and rock cryſtal. He ſhows that Dr. Hill's method is defective and embarraſſing. *Note of the Author.*

When expoſed to the action of heat, it loſes its acid and water of cryſtallization; if ſuddenly heated, it decrepitates, and becomes opaque. By diſtillation in a retort, much water and carbonic acid is obtained; but a conſiderable heat is required to diſengage the latter. After this operation, the ſpar is reduced to the ſtate of quick-lime; and the ſpar may be regenerated by combining quick-lime with the acid obtained in this decompoſition. A diſtillation of chalk, which does not differ from calcareous ſpar, except in its friability and its opacity, has been made by Mr. Jacquin. The Duç de la Rochefoucault, who repeated this experiment with great care, obſerved, that ſtone-ware retorts ſuffer a part of the carbonic acid gas to eſcape. Dr. Prieſtley has eſtabliſhed this fact by many very accurate experiments. A retort of iron, or gun barrel, may be uſed; but a ſmall quantity of inflammable gas is always produced by the action of the water contained in the chalk upon the iron.

Calcareous carbonat, expoſed to a ſtrong heat in crucibles made of clay, is capable of flowing into glaſs, where it touches the veſſel. Mr. D'Arcet has melted ſeveral pieces into a tranſparent glaſs, with a few ſpots. But as Macquer has obſerved that this earthy ſalt did not melt in the focus of Mr. Trudaine's burning lens, it cannot be doubted but that the fuſion obtained by Mr. D'Arcet was produced by the clay of the crucibles.

Calcareous carbonat is not altered by expoſure to pure air; but the contact of the humid atmoſphere, together with the action of the ſun's rays, deprive it of its tranſparency, and deſtroy the coheſion of its laminæ. Its ſurface takes the colours of the rainbow, grows dim, and ſplits off by degrees. It does not appear to be ſoluble in water. Chalk, which cannot by art be diſſolved in this fluid, is nevertheleſs held in ſolution by waters which paſs over beds of cretaceous ſubſtances: ſome waters, ſuch as thoſe of Arcueil, in the neighbourhood of Paris, contain a conſiderable quantity; ſo that in the ſpace of a few months bodies plunged therein become incruſted. The waters of the baths of St. Philip, in Italy, are ſo highly charged with this ſubſtance, that they depoſit it to the thickneſs of about half an inch in the ſpace of a few days. This property is applied to the formation of ſmall tablets and figures; moulds are plunged in theſe waters, and the chalk is depoſited on their internal ſurface.

Calcareous carbonat promotes the vitrification of ſome earthy and ſtony ſubſtances. Mixed with ſilicious earth, it cauſes fuſion, when the latter is in the proportion of one-third.

This ſalt, when naturally mixed with argillaceous earth, forms the ſubſtance called marl. This ſubſtance preſents a great number of varieties, with reſpect to colour, denſity, &c. and melts into a greeniſh yellow glaſs, when urged by a ſtrong heat. It is uſed with great ſucceſs as a manure to fertilize lands.

Barytes and magneſia have no action on calcareous carbonat, by the humid way, the carbonic acid adhering more ſtrongly to the lime than to either of theſe; but calcareous carbonat, treated by fire with theſe alkaline earths, forms a vitreous combination. Mr. Achard has made a numerous ſeries of experiments on all theſe mixtures by vitrification; accounts of which are inſerted in the *Journal de Phyſique.*

Fixed alkalis and ammoniac do not affect calcareous carbonat, their affinity with carbonic acid being leſs than that of lime.

The ſulphuric, nitric, muriatic, and fluoric acids decompoſe it, by ſeizing its baſe, and diſengaging the carbonic acid. If ſulphuric acid be poured on calcareous carbonat, an ebullition is excited, which ariſes from the diſengagement of the carbonic acid in the gaſeous form. Naturaliſts avail themſelves, with great ſucceſs, of this chemical character, to diſtinguiſh calcareous ſubſtances. An exact analyſis of calcareous carbonat may be made by acids. For that purpoſe ſulphuric acid is poured on this ſalt, firſt reduced to powder. The carbonic acid, which eſcapes with effervescence, may be collected by means of a recurved tube, under veſſels of mercury. The effervescence is accompanied with cold, ariſing from the volatilization of the acid. When the proceſs is finiſhed, if the new combination be examined, it is found to be calcareous ſulphat, formed by the ſulphuric acid united to the lime which compoſed the baſe of the former ſalts. Recent experiments have ſhown, that ſome of theſe ſpars contain a ſmall proportion of magneſia, and afford ſulphat of magneſia when diſſolved in the ſulphuric acid. The nitric acid, which naturaliſts commonly employ in their aſſays, produces the ſame effervefcence, when dropped on calcareous carbonat; it diſengages the carbonic acid, and forms calcareous nitrat with its baſe.

The muriatic acid likewiſe ſeparates the acid from calcareous carbonat with violent effervefcence, and forms muriat of lime by combining with its baſe.

The fluoric acid decompoſes it in the ſame manner, and forms calcareous fluat with its baſe.

The boracic acid does not decompoſe calcareous carbonat in the cold, but it produces an effervefcence when mixed with chalk in powder, diluted with a ſufficient quantity of water, and expoſed to heat.

The carbonic acid has the property of rendering carbonat of lime and calcareous matters ſoluble in water. We have already ſeen, in treating of this acid, that it precipitates lime-water, and that the chalk is re-diſſolved, if more acid be added than is ſufficient to produce this effect. The water impregnated with carbonic acid, by remaining on calcareous carbonat in powder, becomes gradually charged with a certain quantity of this earthy neutral ſalt. Many waters contain chalk diſſolved by the medium of this acid; but it ſoon precipitates, when the acid is ſuffered to eſcape by expoſure to air. This effect is much more quickly produced by the action of heat; and for that reaſon boiling is ſucceſsfully employed to correct waters loaded with chalk, which, without this precaution, would be crude or hard.

As chalk is almoſt always ſuſpended by means of the carbonic acid, it is therefore eaſily ſeen why it ſo readily precipitates, and cauſes calcareous depoſitions and incruſtations, as we have obſerved of the waters of Arcueil, and the baths of St. Philip in Italy. When natural hiſtory was leſs enlightened by chemiſtry, ſprings of this kind were called *petrifying waters*, and were by the vulgar reckoned among the number of miracles.

Calcareous carbonat has no action on neutral ſalts with baſe of fixed alkali. It decompoſes ammoniacal ſalts. A calcareous ſalt, formed by the acid of the ammoniacal ſalts and the lime, and alſo carbonat of ammoniac, ariſing from the combination of the carbonic acid with the ammoniac, are obtained. This operation is made, by diſtilling in a ſtone-ware retort, a mixture of one pound of ſal ammoniac, and two pounds of chalk or cretaceous ſpar, in powder. Theſe two ſubſtances muſt be very dry. A receiver or cucurbit of glaſs is adapted to the retort, and the fire is gradually raiſed to a low red heat, the receiver being kept cool with wet cloths, or by a ſmall ſtream of cold water, which runs on it during the whole operation. White vapours paſs over, which condenſe in very pure and white cryſtals on the ſides of the receiver. This is the carbonat of ammoniac. This appears to be the proceſs uſed in England for preparing it; from thence it was formerly exported to every part of Europe, under the name of *ſal volatile of England;* but at preſent it is prepared every where. The reſidue of this operation is calcareous muriat, which is uſually melted, if a briſk heat be given towards the end.

The uſes of ſpar, and calcareous matter in general, are very extenſive, as we have already ſhown in treating of their natural hiſtory; but one of the moſt important of theſe uſes is, the preparation of lime. The burning of lime conſiſts in decompoſing calcareous matters by the action of heat, which deprives them of their acid. Stones compoſed of ſhells, marbles, and moſt calcareous ſpars, are the ſubſtances which afford the beſt lime. But the hard calcareous ſtone, called *lime-ſtone*, is more commonly uſed, eſpecially in the neighbourhood of Paris. Theſe ſtones in France are arranged in a furnace, or kiln, ſo as to form a kind of vault, beneath which a wood fire is lighted, and kept up till a ſtrong flame, without ſmoke, is raiſed about ten feet above the furnace, and till the ſtones become very white. Pit coal and turf begins to be uſed at Paris for the burning of lime.

Good lime is hard, ſonorous, becomes quickly and ſtrongly heated by the addition of water, and emits a denſe vapour during its extinction. If it be not ſufficiently calcined, it is leſs ſonorous, and heats ſlowly: if the calcination has been too great, it is ſemi-vitrified, emits too clear a ſound when ſtruck, and does not eaſily unite with water. The workmen call it *over-burned lime.* We ſhall not here enumerate the uſes of lime, but refer the reader to the hiſtory of that pure ſubſtance.

But we ſhall here add, that ſuch calcareous carbonat as is naturally found mixed with very ſmall fragments of calcareous ſulphat, or gypſum, and which is depoſited in mountains in large regular ſtrata, ſeparated by clay and marl, as is obſerved in the vicinity of Paris, conſtitutes the moſt uſeful lime-ſtone for building. Though we have already ſpoken of this article under the head calcareous ſulphat, we think it proper to reſume the ſubject in this place rather at length, becauſe all treatiſes of natural hiſtory, and of chemiſtry, are deficient in this reſpect. It muſt be recollected, that pure calcareous ſulphat, by calcination, affords only fine plaſter, which makes an incoherent paſte with water, and is employed to caſt ſtatues. Every body knows how eaſily this paſte is broken when dry; a circumſtance which depends on the maſs being alike throughout. This is not the caſe with ſuch plaſter as is proper for building. The ſtone which affords it at Montmartre, and other places, is a kind of breccia, formed of very ſmall granulated cryſtals of ſulphat of lime, together with thin laminæ of calcareous carbonat: the preſence of the latter may be aſcertained by a drop of nitric acid applied to the ſtone, which diſengages the carbonic acid with a ſtrong effervеſcence. When a given quantity of the plaſter ſtone of Montmartre is diſſolved in aquafortis, all the calcareous carbonat is decompoſed, in proportion as the lime unites with the nitric acid. The calcareous ſulphat, which is not ſoluble in this acid, remains behind. The relative quantities of calcareous carbonat and ſulphat in different plaſter ſtones may thus be found; and experience ſhows, that the beſt plaſter ſtone contains more than third its weight of the calcareous carbonat.

The mixed nature of the plaſter ſtone being admitted, it is eaſy to account for the phenomena exhibited in its burning, its extinction, and its hardening. When this earthy ſalt is burned, the calcareous ſulphat which it contains loſes its water of cryſtallization, and becomes friable; the calcareous carbonat, at the ſame time, being converted into lime by the loſs of its acid. In this ſtate, the well burned plaſter is acrid and alkaline; converts the ſyrup of violets to a green; becomes hot with acids without effervеſcence; and loſes its goodneſs by expoſure to air, in proportion as the lime is extinguiſhed by attracting humidity and carbonic acid from the atmoſphere. It abſorbs water with avidity; and with regard to the ſolidity it ſo ſuddenly takes, which is a property oppoſite to thoſe of pure lime, it ariſes from the circumſtance, that when the quick-lime has abſorbed as much water as is neceſſary for its extinction, the calcareous ſulphat, which is interſperſed between its particles, cryſtallizes ſuddenly, and produces the ſame effect as ſand in mortar, by giving ſolidity to the whole.

Laſtly, From this theory it is known, why plaſter may be well preſerved in a hot and dry place, but is quickly deſtroyed by humidity. The ſolubility of its two ſaline principles in water is the cauſe of this phenomenon.

CHAPTER VIII.

GENUS IV. NEUTRAL SALTS, WITH BASE OF MAGNESIA, OR MAGNESIAN SALTS.

WE have already obſerved, in the hiſtory of acids, that magneſia readily combines with thoſe ſalts, and forms ſaline compounds different from thoſe which contain other baſes. Theſe ſalts are not yet perfectly known, few chemiſts having paid particular attention to them. The celebrated Dr. Black is the firſt who made a proper diſtinction between theſe ſalts and other terreſtrial-ſaline bodies, with which they were before confounded.

Magneſian ſalts poſſeſs generic characters ſufficient to diſtinguiſh them. They are almoſt all bitter and ſalt; the greateſt part cryſtallize regularly, though with difficulty; in general they are very ſoluble in water, ſome even attracting the humidity of the air; and they are more eaſily decompoſed than ammoniacal and calcareous ſalts. Barytes, lime, ammoniac, and the two fixed alkalis, deprive them of their acid. The decompoſition by volatile alkali is partial; for this ſubſtance remains partly united to the acids, at the ſame time as the magneſia, and then forms triple ammoniaco-magneſian ſalts.

We ſhall examine ſix of theſe ſalts in the preſent chapter; namely, ſulphat of magneſia, or Epſom ſalt, nitrat of magneſia, muriat of magneſia, borat of magneſia, fluat of magneſia, and carbonat of magneſia.

Species I. Sulphat of Magneſia, or Epſom Salt.

The neutral ſalt, compoſed of magneſia, united to the ſulphuric acid, has been called Epſom ſalt, from the name of a ſpring in England from which it was formerly obtained: it exiſts likewiſe in the waters of Egra, Sedlitz, and Seydſchutz. Its true name is ſulphat of magneſia, or magneſian ſulphat.

This ſalt has a very bitter taſte, and on that account has been called *ſal cathartieus amarus:* it is met with in commerce in the form of very ſmall needles, terminated by acute pyramids; in this ſtate it much reſembles ſulphat of ſoda, or *Glauber's ſalt*, but its taſte is more bitter. It does not effloreſce in the air; and its regular cryſtallization is very different from that which we have juſt deſcribed. By a ſpontaneous evaporation, it is obtained in fine quadrangular priſms, terminated by quadrangular pyramids, all the ſurfaces being ſmooth and without furrows; its cryſtals in general are ſhorter and larger than thoſe of ſulphat of ſoda; and it likewiſe differs from that perfect neutral ſalt in all its other properties.

Sulphat of magneſia retains a ſufficient quantity of the water of cryſtallization to admit the aqueous liquification. A very ſlight heat is ſufficient to melt it; and it congeals, by cooling, into a maſs of no determinate form. Continued application of heat dries it into a white friable maſs, which is merely the ſalt deprived of its water of cryſtallization: it does not experience the true igneous fuſion but by an extreme heat. The water of cryſtallization in this ſalt is nearly half its weight.

Macquer and other chemiſts affirm, that it becomes ſlightly moiſtened by expoſure to air, and that it may be thereby diſtinguiſhed from ſulphat of ſoda, which effloreſces. But Bergman, on the contrary, affirms, that ſulphat of magneſia, expoſed to a dry air, loſes its tranſparency, and is at length reduced into a white powder; and he affirms, that the ſalt ſold in the form of ſmall needles, is humid and deliqueſcent, on account of the muriat of magneſia it contains. Mr. Butini, citizen of Geneva, to whom we are indebted for a ſeries of valuable inquiries concerning magneſia, affirms, that he found in Engliſh Epſom ſalt, a ſufficient quantity of ſulphat of ſoda, or Glauber's ſalt, to which the effloreſcence might be attributed; but that ſulphat of magneſia, well purified, though its tranſparency is diminiſhed by expoſure to air, is very far from effloreſcing like ſulphat of ſoda, which is entirely reduced to powder at the end of a ſhort ſpace of time.

Sulphat of magneſia is ſo ſoluble in water, that no more than twice its weight of cold, or half its weight of hot water, are required to hold it in ſolution. It cryſtallizes by cooling; but very regular cryſtals can only be produced by ſpontaneous evaporation.

This ſalt is not altered by ſilicious or aluminous earths.

Barytes decompoſes it, becauſe its affinity to the ſulphuric acid is greater than that of magneſia.

Lime decompoſes it for the ſame reaſon. If a ſmall quantity of ſulphat of magneſia be added to lime-water, or if the latter be added to a ſolution of the ſalt, a precipitate is formed, conſiſting of magneſia and calcareous ſulphat; this precipitation is a diſtinctive character, by which ſulphat of magneſia may be known from that of ſoda.

Pure fixed alkalis likewiſe decompoſe ſulphat of magneſia. The cauſtic ammoniac decompoſing this ſalt, and having no effect on calcareous ſulphat, is a proof that it has a ſtronger affinity than magneſia, and a weaker than lime, with the ſulphuric acid: it may therefore ſerve as a teſt of the preſence of ſulphat of magneſia in waters. Hence, likewiſe, pure magneſia is obtained by means of the cauſtic ammoniac. Bergman obſerves, that pure ammoniac does not completely precipitate the magneſia from Epſom ſalt, but that part remains undecompoſed. The liquid holds in ſolution ammoniacal, and magneſian ſulphats. Some chemiſts have imagined, that theſe two ſalts, combining together, formed a triple ſalt, or compound of an acid united to two baſes: but there is a manifeſt error in this opinion; for though theſe ſalts are found in the ſame water, one conſiſts of the ſulphuric acid united to ammoniac, and the other of the ſame acid combined with magneſia. Each has a portion of acid; and it is not one and the ſame acid which adheres to the two baſes: but theſe two ſulphats have a very great affinity for each other; they cryſtallize together, and form what may be called a *triple ſalt*, or *ammoniaco-magneſian ſulphat*.

The action of ſulphat of magneſia on neutral ſalt, with baſe of fixed alkali and ammoniac, is not yet known; it is probable that it may decompoſe nitric and muriatic ſalts of theſe genera by double affinity.

Mr. Quartremer Dijonval affirms, in a letter to Morveau (*Journal de Phyſique* for May 1780), that when a ſolution of ſulphat of magneſia is added to a ſolution of ſulphat of ammoniac, the former ſalt is totally precipitated without decompoſition, in the form of cryſtals of conſiderable magnitude, which may be known by the taſte, &c. He attributes this effect to the ſulphat of ammoniac ſeizing the water from the magneſia, which he thinks cryſtallizable in this manner: but this is an error; for the ſalt, which cryſtallizes in this operation, is a true triple ſalt, or ammoniaco-magneſian ſulphat, as I am aſſured by experience.

It is certain, that ſulphat of magneſia and the carbonic ſalts mutually decompoſe each other. When a ſolution of carbonat of potaſh, or ſoda, is poured into a ſolution of ſulphat of magneſia, a double decompoſition and combination take place; the ſulphuric acid of the Epſom ſalt unites to the fixed alkalis, and the carbonic acid, ſeparated from the latter, ſeizes the magneſia, and forms a neutral ſalt, known by the name of *mild* or *efferveſcent magneſia*, which we ſhall call *carbonat of magneſia*. By this proceſs, the mild magneſia, uſed in medicine as an excellent purge, is prepared, as will be ſeen more at large at the end of this chapter.

A ſolution of ſulphat of lime, mixed with a ſolution of ſulphat of magneſia, affords a precipitation of the latter, according to Mr. Dijonval: the precipitate is ſcarcely ſenſible on account of the ſmall quantity of calcareous ſulphat diſſolved in the water. Nitric and muriatic calcareous ſalts decompoſe ſulphat of magneſia; but we do not think it proper to conclude with Mr. Dijonval, that the nitric and muriatic acids have an affinity to the ſulphuric acid with magneſia, as theſe experiments certainly depend on double affinity.

Bergman affirms, that a centenary of cryſtallized ſulphat of magneſia contains nineteen parts of pure magneſia, thirty-three of ſulphuric acid, and forty-eight of water.

Sulphat of magneſia is employed in medicine with great ſucceſs; it is a very uſeful purge, and at the ſame time has an opening quality. It is even preferred to other purgative ſalts, on account of its great ſolubility; it is adminiſtered either alone diſſolved in water, in a doſe from one to two ounces, or as an auxiliary medicine in the quantity of one or two drachms. It mineralizes moſt natural purgative waters, eſpecially thoſe of Egra, Sedlitz, Seydſchutz, &c. but it is always accompanied with muriat of magneſia[i].

Species II. Nitrat of Magneſia.

The nitrat of magneſia, called till now magneſian nitre, or nitrated magneſia, has been examined by Bergman. This illuſtrious chemiſt affirms, that a ſolution of this ſalt made by art, affords, after proper evaporation, priſmatic, quadrangular, ſpathoſe cryſtals, without pyramids.

This ſalt has an acrid and very bitter taſte; it is decompoſed by heat, attracts the humidity of the air, and is very ſoluble in water[k]. It cannot be obtained in cryſtals, but by a ſlow evaporation; and the laws of its cryſtallization are not yet ſufficiently known to enable us to obtain it with certainty in a regular form, as is done with a great number of other ſalts. It is decompoſed by barytes, lime, and the fixed alkalis.

As nitrat of magneſia is diſſolved in the mother-waters of nitre, Morveau propoſes to obtain the magneſia in the large way, by precipitating it with lime-water. This proceſs might be very advantageous in point of facility and cheapneſs: but the ſame chemiſt having obſerved, that freſh lime-water precipitates pure calcareous nitre, when the water of ſolution is not in ſufficient quantity, the magneſia obtained by this proceſs will not poſſeſs the degree of purity requiſite for a medicine of ſuch utility, if the precipitation be effected on mother-waters which are not diluted with a very large quantity of fluid.

The ſulphuric and fluoric acids diſengage the acid from nitrat of magneſia; boracic acid likewiſe ſeparates it by the aſſiſtance of heat, in conſequence of its fixity: theſe properties of this ſalt were diſcovered by Bergman. Mr. Quartremer Dijonval, who has made inquiries into many combinations of magneſia, found ſome of the properties of nitrat of magneſia very different from thoſe attributed to it by the chemiſt of Upſal. He aſſerts, that he obtained cryſtals of magneſian nitrat which do not deliqueſce; and even adds, that the magneſian ſalts are as cryſtallizable and effloreſcent, as the calcareous ſalts are greedy of moiſture.

The nitrat of magneſia ſeems capable of decompoſing by double affinity the ſulphats of potaſh, ſoda, and ammoniac; but theſe decompoſitions are not ſenſible in the mixture of the ſolutions of the different ſalts, as thoſe are which are effected with calcareous nitrat: becauſe the nitrats of potaſh, ſoda, and ammoniac, as well as the ſulphat of magneſia, are all very ſoluble in water; while the ſulphat of lime, formed by the decompoſition of the ſulphats of potaſh, ſoda, and ammoniac by calcareous nitrat, affords a very plentiful precipitate. The effect of theſe double affinities, produced by the nitrat of magneſia, may however be ſeen by evaporating the fluid; the nitrats formed by the combination of the nitric acid with the alkalis, and the ſulphat of magneſia produced by the union of the ſulphuric acid of the decompoſed ſalts, with the baſe of magneſian nitrat, are by that means obtained.

Mr. Dijonval mentions a fact, which deſerves all the attention of chemiſts; it is the precipitation of magneſian nitrat by the addition of calcareous nitrat. When tranſparent and very pure ſolutions of theſe two ſalts are mixed, the magneſian nitrat is immediately depoſited in the cryſtalline form, without being at all decompoſed; the fluid retaining the calcareous nitrat in ſolution. It is very ſingular that two ſalts, which when ſeparate had ſufficient water to hold them in perfect ſolution, ſhould, when mixed, exhibit the appearance of the precipitation and cryſtallization of one of them. Mr. Dijonval thinks, as we have already announced, that this depends on the ſtrong tendency of the calcareous nitrat to unite with water; this ſalt, according to him, being capable of abſorbing a larger quantity of water than is neceſſary to hold it in ſolution, and the nitrat of magneſia, on the contrary, tending ſtrongly to cryſtallize, the former immediately ſeizes the water which held the latter in ſolution; the magneſian nitrat is of courſe precipitated in the cryſtalline form: this explanation does not, however, appear to remove all difficulties. How, in fact, can any ſalt, however ſoluble, or however ſtrong its diſpoſition to combine with water may be, ſeize the water from another ſalt, while itſelf is already united with a ſufficient quantity to hold it in ſolution?

If it be replied that it is not ſaturated with water, it ſhould be obſerved, that there will be a point of ſaturation at which calcareous nitrat would ceaſe to precipitate the nitrat of magneſia in this manner, and this fact ought to have been ſhown. If the ſuppoſition be even admitted, how can the calcareous nitrat ſeize the water of cryſtallization of the magneſian nitrat, ſince the magneſian nitrat appears to be precipitated in the cryſtalline form? *Laſtly*, How is it poſſible that magneſian nitrat, after being deprived of the water of its cryſtallization by calcareous nitrat, can be inſtantaneouſly precipitated in cryſtals? We therefore think that ſome circumſtance eſcaped Mr. Dijonval in the phenomena he obſerved, and that they depend on a cauſe which will not be clearly aſcertained till the experiment has been repeated in ſeveral different manners, with regard to the quantity of water, of ſalts, the temperature, &c.

Magneſian nitrat is not uſed in the arts, nor in medicine. Its ſtrong taſte, its deliqueſcence, and all its other properties, ſhow, that it would act ſtrongly on the animal economy; yet it deſerves to be tried as a ſolvent and aperient medicine.

Species III. Muriat of Magneſia.

This ſalt, which is a ſaturated combination of muriatic acid and magneſia, exiſts in all ſalt waters, and in all ſuch as contain ſulphat of magneſia in ſolution, as the waters of Epſom, Egra, Sedlitz, Seydſchutz, and many others; it is much more common than is ſuppoſed.

Magneſian muriat has a very bitter and hot taſte. Bergman affirms that it cannot be obtained in cryſtals, but by ſuddenly expoſing its ſolution, firſt concentrated by evaporation, to a great degree of cold. It is then in the form of ſmall and very deliqueſcent needles. This ſolution moſt commonly has the appearance of a tranſparent jelly. Mr. Dijonval, who affirms that he has obtained this ſalt in a regular and permanent form, thinks it is rather efflореſcent than deliqueſcent.

Muriat of magneſia is decompoſed, and loſes its acid, by the action of fire. The laſt portions of acid are not diſengaged but with great difficulty; the magneſia remains cauſtic after the operation.

This ſalt, when expoſed to the air, appears to attract humidity ſtrongly, and quickly falls into deliqueſcence. Bergman, and many other chemiſts, have mentioned this property. Mr. Dijonval is the only one who has aſſerted that the muriat of magneſia, as well as magneſian nitrat, effloreſces, inſtead of attracting humidity; but this aſſertion requires to be eſtabliſhed by repeated experiments.

Magneſian muriat is very ſoluble in water, and appears to be held in ſolution by leſs than its own weight of that fluid. It is very difficult to obtain it in perfect cryſtals; evaporation by heat does not ſucceed well, becauſe the fluid becomes thick, and almoſt always takes the gelatinous form in cooling. There are more hopes of ſucceſs from the ſpontaneous evaporation of a ſolution of this ſalt during the heat of ſummer; and this method is found to afford cryſtals, though with much difficulty.

The muriat of magneſia, heated in a retort with ſilicious and argillaceous earth, gives out its acid; but as this is alſo diſengaged by mere heat, the decompoſition in the preſent caſe cannot be attributed to the earths.

Barytes and lime decompoſe this ſalt, and precipitate the magneſia. As the mother-waters of the muriat of ſoda of ſalt-ſprings contain muriat of magneſia mixed with calcareous muriat, the magneſia may be precipitated in the large way, and at a ſmall expence, by means of lime-water.

Pure fixed alkalis, and cauſtic ammoniac, have more affinity than magneſia to the muriatic acid, and therefore precipitate it from this ſalt. The water holds in ſolution the muriat of potaſh, ſoda, or ammoniac, according to the nature of the alkali made uſe of. The ammoniac does not decompoſe it completely, but forms a triple cryſtallizable muriatic ſalt, with the remaining portion of magneſian muriat.

The ſulphuric and nitric acids decompoſe this ſalt, and ſeparate the muriatic acid with effervеſcence. To effect theſe decompoſitions, a mixture of one part of either of theſe acids, and two parts of muriat of magneſia, are to be expoſed to heat in a retort. The acid of the latter becomes volatilized, while the ſtronger acid combines with the magneſia, and forms ſulphat and nitrat of magneſia. Boracic acid likewiſe diſengages the muriatic acid by heat.

Muriat of magneſia decompoſes the ſulphuric and nitric ſalts, with baſe of fixed alkali and ammoniac, by the way of double affinity; but in order to be aſſured that theſe decompoſitions take place, the mixture muſt either be evaporated, or ſpirit of wine added, which ſeizes the water; otherwiſe the new ſaline reſults will remain diſſolved in the fluid.

According to Mr. Dijonval, if the ſolutions of muriat of potaſh and of magneſia are mixed, the latter ſalt is precipitated in cryſtals, in conſequence of its ſtrong diſpoſition to cryſtallize, compared with that of the muriat of potaſh, which retains the water of ſolution. It is very difficult to conceive, admitting the opinion of this chemiſt, how the muriat of potaſh, which is much inferior to the muriat of magneſia in point of ſolubility and deliqueſcence, can deprive this laſt of the water which holds it in ſolution. If a ſolution of magneſian muriat be mixed with a ſolution of calcareous muriat, the former is precipitated in cryſtals, according to the ſame chemiſt. All theſe aſſertions require to be confirmed by new experiments, before they can be admitted as part of the elements of chemical ſcience. It is very probable that the precipitated cryſtals are not pure, but belong to the claſs of triple ſalts.

Magneſian muriat is of no uſe, but we think it might be advantageouſly employed as an opening medicine; it is continually adminiſtered in ſmall quantities in Epſom ſalt, Sedlitz water, and the impure marine ſalts, theſe ſubſtances always containing it.

Species IV. Magneſian Borat.

This name may be given to the combination of boracic acid with magneſia. It is ſcarcely known. Bergman obſerved, that magneſia, added to a ſolution of boracic acid, was diſſolved, though ſlowly. The fluid, by evaporation, affords granulated irregular cryſtals.

This ſalt melts in the fire without decompoſition. Acids decompoſe it by combining with the magneſia, and diſengaging the boracic acid. Spirit of wine combines with the acid, and leaves the magneſia ſeparate: it does not therefore adhere ſtrongly to the acid of borax.

Hence it appears, that for want of experiments, we are ignorant of almoſt all the properties of this ſalt.

Species V. Magneſian Fluat.

The combination of magneſia with the fluoric acid, which may be called magneſian fluat, is not more known than the magneſian borat. Bergman is the only chemiſt who mentions it. According to him, the fluoric acid rapidly diſſolves magneſia, great part of the ſalt being depoſited in proportion as the ſaturation is effected.

The ſolution affords, by ſpontaneous evaporation, a kind of tranſparent froth, which hangs to the ſides of the veſſel, and preſents ſome long and very ſlender cryſtalline needles. Sparry cryſtals are likewiſe formed at the bottom of the veſſel in hexagonal priſms, terminated by a low pyramid compoſed of three rhombs. This ſalt is not changed by the moſt violent heat, and no acid decompoſes it in the moiſt way. It is one of thoſe neutral fluor ſalts, which deſerve to be particularly examined.

Species VI. Carbonat of Magneſia.

This ſalt, denominated *mild* or *effervescent magneſia* by its diſcoverer, Dr. Black, is formed by the intimate union of magneſia with the carbonic acid.

The carbonat of magneſia has moſt commonly the appearance of an earth, or very white powder. However, Bergman, and Mr. Butini of Geneva, obtained it in a cryſtalline form by the proceſs we ſhall deſcribe below. It is capable of uniting with various quantities of its acid, as all cretaceous ſalts in general are; and its properties differ accordingly. Its taſte is crude and earthy; but its effect is more ſenſible on the inteſtines, as appears by its acting as a purgative.

Expoſed to the fire in a crucible, its loſes its acid and water. Mr. Tingry, apothecary at Geneva, obſerved, that when it is calcined in large quantities, it boils, and has the appearance of a fluid; a phenomenon produced by the diſengagement of its acid gas. A light ſmoke ariſes from the crucible, which being depoſited on the ſurrounding bodies, is found to be powder of magneſia, carried off by the current of carbonic acid. If a hot body be plunged therein, it adheres to it, according to the ſame chemiſt; a cold ſubſtance takes up, by adheſion, a ſtill greater quantity: towards the end of the operation, the magneſia ſhines, with a blueiſh and phoſphoric light, very ſenſible in the dark.

If carbonat of magneſia be calcined in cloſe veſſels with a pneumatic apparatus, the water and acid may be preſerved. Mr. Butini, who made this experiment with great accuracy, affirms, that thirty-two grains of common magneſia, by which he means ſuch as is prepared for medical purpoſes, and is not entirely ſaturated with acid, contains about thirteen grains of pure earth, twelve grains of acid, and ſeven of water. Bergman eſtimates that this ſalt contains in the hundred, twenty-five or thirty parts of acid, thirty of water, and forty-five of pure magneſia. If it be more ſtrongly heated after it has loſt its acid, its parts agglutinate, and become hard like pure or cauſtic magneſia.

Carbonat of magneſia is not ſenſibly altered by expoſure to air; yet, as it gathers into lumps when kept in a moiſt place, it ſeems to be ſlightly deliqueſcent.

Water diſſolves but an exceedingly ſmall quantity of this ſalt; and this ſolubility varies accordingly as the quantity of carbonic acid is greater or leſs. If it be mixed with a ſmall quantity of water, it forms a kind of paſte, which is ſcarcely ductile, and dries without becoming firm, or contracting in its dimenſions. Common magneſia is ſoluble in the proportion of about a quarter of a grain to an ounce of the fluid, as may be aſcertained by evaporation. But there are means of diſſolving magneſia in much greater quantities, as we ſhall preſently obſerve.

Carbonat of magneſia is not decompoſed by the pure earths; lime deprives it of its acid by greater affinity. Lime-water poured into a ſolution of this ſalt, occaſions a very ſenſible precipitate, however ſmall the quantity of this neutral ſalt may be. The precipitate conſiſts of carbonat of lime, and a ſmall quantity of pure magneſia, which is nearly inſoluble.

Pure fixed alkalis and cauſtic ammoniac decompoſe it likewiſe, on account of their ſtronger affinity with the carbonic acid. In theſe mixtures, carbonats of potaſh, ſoda, or ammoniac, are formed, and the pure magneſia is precipitated.

The ſulphuric, nitric, and muriatic acids, decompoſe carbonat of magneſia, and render the analyſis of this neutral ſalt complete. They unite to magneſia, with which they have a ſtronger affinity than the carbonic acid, and diſengage the latter in the aerial form. The carbonic acid may be known by its uſual characters. Mr. Butini has obſerved that the acids diſengage leſs carbonic acid than is extricated by the action of fire; for example, the muriatic acid diſengages more than the nitric, and the nitric more than the ſulphuric. Whence he concludes, that the neutral ſalts, formed by magneſia with acids, retain a portion of the carbonic acid.

The carbonic acid renders carbonat of magneſia much more ſoluble than it is naturally. The new experiments of Mr. Butini depend chiefly on this circumſtance. He has diſcovered, that when common magneſia, which is not ſaturated with the carbonic acid, is thrown into gaſeous water, or water charged with this acid, the magneſia immediately becomes ſaturated, by depriving the water of a portion of the acid, and is not diſſolved, unleſs the water likewiſe contain a large quantity of the ſame acid. This ſolution converts ſyrup of violets to a green. When expoſed to the cold, it loſes its ſuperabundant air, but without any ſeparation of the magneſia, which remains perfectly combined, even when the water is frozen. If a ſolution of magneſia with exceſs of acid be heated, it becomes clouded, and reſumes a kind of tranſparency by cooling. This ſingular phenomenon preſents, as Mr. Butini has well obſerved, a new kind of ſalt, whoſe character is that of being more ſoluble in cold than in hot water. The more a gaſeous ſolution is charged with magneſia, the more quickly will its tranſparency be diſturbed by heat. In order to obſerve the tranſition from opacity to tranſparency by cooling, the ſame chemiſt directs to take a ſolution, which contains two grains per ounce, and to heat it to 170 degrees of Fahrenheit's thermometer: it then becomes of a milky appearance, and all the magneſia, which precipitated by heat, is re-diſſolved by cooling.

Bergman having affirmed, that the ſolution of magneſia charged with carbonic acid, afforded, by ſlow evaporation, cryſtals, ſome of which are in tranſparent grains, and others reſembling two collections of radii diverging from the ſame point; Mr. Butini obſerved the phenomena of this cryſtallization with great care. He evaporated, by the gentle heat of a lamp, a ſolution charged with nine grains of the ſalt per ounce of water. A pellicle was firſt formed at the top, whoſe under ſurface, as well as the ſides of the veſſel, had many tufts of cryſtals adhered to it. The reſidue preſented brilliant needles, compoſing ſmall hemiſpheric maſſes of diverging fibres. Theſe needles, which were not a line in length, being examined by the microſcope, were found to be long ſix-ſided priſms, truncated by a hexagon, and reſembling ſome ſpars.

Mr. Butini has likewiſe diſcovered another method of cryſtallizing carbonat of magneſia; it conſiſts in expoſing to the air an acid ſolution of this ſalt precipitated by heat. At the end of a few days cryſtals are obtained ſimilar to thoſe afforded by evaporation. Magneſia precipitated from Epſom ſalt by carbonat of potaſh, and dried, affords no cryſtals; but when it is mixed in water, flocks of an irregular figure are formed; but a ſolution of ſulphat of magneſia newly precipitated by the ſame ſalt affords needle-form cryſtals at the end of ſome days. The ſame ſolution, ſeparated from its precipitate by the filtre, likewiſe afforded needles of magneſia. I have often obſerved that a ſolution of carbonat of magneſia prepared for chemical experiments, and preſerved in well-cloſed glaſs veſſels, affords, at the end of a certain time, a large quantity of very fine brilliant needles, which examined by the magnifier, were found to be ſix-ſided priſms.

Perfect neutral ſalts and carbonat of magneſia experience no change by ſolution in the ſame water, excepting only that they increaſe the ſolubility of the latter in water, according to Mr. Butini. Carbonat of potaſh, however, deprives it of this property.

Calcareous neutral ſalts are decompoſed by double affinity by effervescent magneſia. As lime has a ſtronger affinity with acids than magneſia, the decompoſitions muſt take place, in conſequence of the preſence of carbonic acid, to which lime has a ſtrong affinity, and quits its acid to ſeize this, provided another body be preſent with which the diſengaged acid can combine; conſequently, when a ſolution of carbonat of magneſia is poured into a ſolution of ſulphat of lime, calcareous nitrat or muriat, the ſulphuric, nitric, or muriatic acid, quits the lime to unite with the magneſia, with which it forms ſulphat, nitrat, or muriat of magneſia, while the lime combining with the carbonic acid, is precipitated in the form of chalk.

Magneſia therefore acts in the ſame manner as ammoniac. When either of theſe are pure and cauſtic, they cannot decompoſe calcareous ſalts, becauſe of the greater affinity of the lime to acids. But when they are united to carbonic acid, they then effect the decompoſition by double affinity.

Carbonat of magneſia is uſed in medicine under the name of mica, or white magneſia; it was formerly made with the mother-water of nitre evaporated to dryneſs, or precipitated by fixed alkali; it was firſt known by the name of *Count Palma's powder*, *powder of Sentinelli.* It has likewiſe been called *laxative polychreſt powder* by *Valentini*, *white magneſia of nitre*, *magneſia of common ſalt*, becauſe it was likewiſe obtained from the mother-water of this laſt ſalt. But the medicine, ſo prepared, always contains calcareous earth, and other foreign ſubſtances. The magneſia at preſent uſed is commonly precipitated from ſulphat of magneſia by the fixed vegetable alkali or carbonat of potaſh. Mr. Butini has deſcribed a proceſs for obtaining very fine magneſia in the greateſt poſſible quantity: a certain quantity of potaſh is diſſolved in double its weight of cold water, and expoſed to the air for ſome months, if time permits, that it may abſorb carbonic acid from the atmoſphere. This being filtered, a ſolution of an equal weight of ſulphat of magneſia in four or five times its weight of water is made; the ſolution is filtered, and freſh water added in about fifteen times the weight of the ſalt. This liquor is heated, and when it boils, the alkaline ſolution is poured in. A precipitate of magneſia being formed, the mixture muſt be agitated and poured on a filter of paper. The precipitate muſt be waſhed on the filter with boiling water, to carry off the ſulphat of potaſh it may contain. It is then taken from the filter, and thinly ſpread on papers, to dry by the heat of a ſtove; when dry, it is in white pieces, eaſily broken into a very fine powder, which adheres to the ſkin.

This magneſia combined with carbonic acid, as a purge, is to be preferred to that which is cauſtic, becauſe it is much more ſoluble; it is given in the doſe of one or two ounces, according to circumſtances. Cauſtic magneſia, on the contrary, is preferable as an abſorbent, and it is therefore neceſſary to be provided with both; the principal reaſon of this preference of each, and the neceſſity of keeping both kinds of magneſia in the ſhops, has been well explained by Macquer, in a paper preſented to the Royal Society of Medicine. When magneſia is adminiſtered as an abſorbent, it is intended to deſtroy and neutralize a diſengaged acid in the firſt paſſages, as happens with infants, young girls, women in childbed, &c. The acid in the ſtomach is certainly ſtronger than the carbonic acid; ſo that when mild magneſia is taken, it produces an efferveſcence proportional to the quantity of diſengaged acid in the firſt paſſages. The carbonic acid, during this effervеſcence, diſtends the ſtomach, and often occaſions pain, nauſea, vomitings, difficulty of reſpiration, and many other ſpaſmodic accidents, according to the ſenſibility of the ſubject. In theſe circumſtances the pure magneſia is greatly to be preferred, as it abſorbs acidities with equal readineſs, and occaſions no effervеſcence.

When, on the contrary, magneſia is to be given as a purge, and in caſes where there are no ſymptoms of acidity in the firſt paſſages, the carbonat of magneſia may be uſed. The acid is not then diſengaged, and conſequently the accidents to be feared from that circumſtance do not take place.

Mr. Butini propoſes an artificial mineral water made with gaſeous water charged with magneſia; he obſerves that ſuch a fluid may contain three drachms of magneſian earth in the pound, and is not more difficult to prepare than the other artificial mineral waters. The manipulation is abſolutely the ſame in both, and there is no doubt but it might in many caſes be uſed with ſucceſs. See my Memoirs on the Magneſian Salts in the ſecond volume of the *Annales de Chemie.*

CHAPTER IX.

GENUS V. ARGILLACEOUS NEUTRAL SALTS, OR ALUMINOUS SALTS.

VERY pure alumine combines well with moſt acids, and produces neutral ſalts, diſtinguiſhed by the appellation *argillaceous* or *aluminous ſalts.* This genus of ſaline matters, if we except the firſt ſpecies, has not yet been examined by chemiſts with ſufficient care, and therefore their properties are leſs known than thoſe of the four preceding genera. Aluminous ſalts are in general leſs perfect than all the neutral ſalts we have yet ſpoken of. They yield their acids to fixed alkalis, ammoniac, barytes, lime, and magneſia: their taſte is acrid and aſtringent.

The preſent genus comprehends ſix ſpecies; alum, or ſulphat of alumine, argillaceous nitrat, argillaceous muriat, argillaceous borat, aluminous fluat, and carbonat of alumine.

Species I. Sulphat of Alumine, or Alum.

Alum is a neutral ſalt, formed by the combination of the ſulphuric acid with alumine or pure clay, and may therefore be named ſulphat of alumine. Chemiſts have not always been agreed concerning the baſe of alum; ſome chemiſts have diſtinguiſhed it from argil, and called it by the peculiar name of *aluminous earth*, or *earth of alum.* Margraaf has ſhown, that earth of alum, kneaded up with ſilex in fine powder, forms clay. Hellot, Geoffroy, Pott, and eſpecially Baumé, have formed true alum with clay and the ſulphuric acid. And if the true characters of argil are to become ductile with water, to contract and become hard by heat, the aluminous earth having all theſe properties in the moſt eminent degree, ought to be regarded as the pureſt clay. This opinion is at preſent univerſally admitted among chemiſts. Hence we ſee the neceſſity of diſtinguiſhing this earthy baſe of alum by the particular name of *alumine;* becauſe clay, however pure it may be, always contains ſilex.

Sulphat of alumine or alum has a taſte at firſt ſweetiſh, and afterwards ſtrongly aſtringent; it reddens blue paper; whence it appears that a portion of its acid is unſaturated: it aſſumes a very regular form, hereafter to be deſcribed.

Alum is ſcarcely ever found pure in nature; it is ſometimes found in the neighbourhood of volcanos, but always mixed with argil. Mineralogiſts, eſpecially Wallerius, have diſtinguiſhed ſeveral ſpecies of native alum, ſuch as the ſolid alum, cryſtallized alum, alum in efflореſcence, white, grey, brown, black, aluminous earths, aluminous ſchiſti.

Several ſpecies of alum are found in commerce.

1. Rock alum, in conſiderable maſſes; tranſparent. Bergman thinks that this name is derived from the city of Rocca, in Syria, now called Edeſſa, where the moſt ancient manufacture of this ſalt was eſtabliſhed, and not becauſe its form reſembles a rock, or ſtone, or becauſe it is obtained from rocks or ſtones, as ſeveral authors have affirmed. This ſpecies of alum is very impure.

2. Roman alum, which is prepared in the territory of Civita Vecchia, and obtained from a place, named in Italian, *Aluminiere della Tolfa*. This alum is in pieces of the ſize of eggs; it is covered with a reddiſh efflореſcence, and is ſuppoſed to be pure when that efflореſcence is ſeparated.

3. Naples alum, extracted from a peculiar earth at the Solfatara; it is in larger maſſes than the Roman alum, and one of its ſurfaces is covered with pyramidal cryſtals.

4. Alum from Smyrna. The moſt ancient manufactures of alum appear to have been eſtabliſhed near Smyrna and Conſtantinople. This alum is only found in cabinets of natural hiſtory.

5. Alum made in France. It is prepared in many manufactories, eſpecially at Javel, near Paris.

6. Alum may likewiſe be extracted from efflореſcent ſchiſti and volcanic products. I have extracted a conſiderable quantity from an earth ſent to me out of Auvergne. This ſalt may be extracted from many ſubſtances of the like nature found in France, by which means we might take this branch of trade out of the hands of foreigners.

Alum is likewiſe extracted from earths and ſtones in many parts of Germany, where there have been manufactories ſince the year 1544; and alſo in England, Spain, Sweden, and in moſt parts of Europe.

Beckman has written the hiſtory of the manufacture of alum, in a long diſſertation, which may be ſeen in the Gottingen Acts. From the inquiries of this learned man it appears, that the orientals were the firſt who prepared or extracted alum from what the ancients, and Pliny in particular, called *chiſton*, *trichites*, *calchites*, and which they ſeem to have confounded with the alum; and the ϛυπτῆϱία of the Greeks appears rather to anſwer to the different ſtates of martial ſulphat, or green copperas. The Italians took the alum manufactures in the neighbourhood of Conſtantinople on leaſe: about the year 1459, Bartholomew Perdix, or Pernix, a Genoeſe, diſcovered alum ore in the Iſland of Iſchia; about which time Juan de Caſtro founded another at La Tolfa; and a great number of manufactories were ſoon after eſtabliſhed in Italy, more eſpecially when Pope Pius II. prohibited the importation of alum from the eaſt. This art was afterwards carried into Spain, Germany, England, and Sweden, towards the beginning of the ſeventeenth century. (Vide *Beckman.*)

The preparation of ſulphat of alumine varies greatly in different countries, and according to the different matters from which it is obtained. Bergman, who has written a very valuable diſſertation on this ſubject, divides the ſubſtances, commonly called *alum ores*, into two ſpecies, namely, ſuch as contain alum ready formed, and ſuch as contain only its principles. The firſt require only to be lixiviated, in order to obtain the alum: the earth of Solfatara is of this kind, as is likewiſe that of Auvergne, before ſpoken of. It is mixed with water, in leaden caldrons ſunk in the earth; the natural heat of the ſoil favours the ſolution and cryſtallization of the alum, which is purified by a ſecond ſolution in water. The alum earth of Auvergne might be lixiviated in the ſame manner, and the alum made to cryſtallize in leaden caldrons by evaporation.

The natural ſubſtances, which contain only the principles of ſulphat of alumine, are much more common than the foregoing, and require previous preparation. It is neceſſary either to calcine them, or to expoſe them to the air, according to their reſpective natures. The aluminous ſchiſti muſt be calcined, in order to burn the bitumen which colours them, and to decompoſe the pyrites, which afford the alum. Bergman found, that this ſchiſtus does not afford a particle of alum by waſhing with water before it is calcined. Expoſure to air produces the ſame effect on pure pyrites, ſprinkled with water. The ſpontaneous decompoſition of theſe ſubſtances produces ſulphuric acid, which unites with the clay, and forms alum. The pyrites, fallen into efflorefcence, are lixiviated with water, and the iron it contains is ſuffered to ſubſide; after which it is evaporated, and ſet to cryſtallize in caſks: the ſalt is depoſited in large cryſtals. Strong ſoap lye is ſometimes uſed to forward the cryſtallization. Such is the proceſs uſed in many manufactories; but theſe alums obtained from pyrites always contain iron; that which is extracted from ſtones, in which it exiſts ready formed, as the Roman alum, is much purer. The alum formed by the direct combination of the ſulphuric acid with clay, is often mixed with a certain quantity of iron, becauſe the coloured clay uſed in the preparation always contains a portion of that metal.

Sulphat of alumine, regularly cryſtallized, is a perfect octahedron, conſiſting of two tetrahedral pyramids, united at their baſes. This form varies greatly, according to the circumſtances in which the cryſtallization is performed; the octahedron being more or leſs truncated, irregular, acute, flattened, and the cryſtals are often joined, and as it were included one within another. Romé de Lille has carefully deſcribed all theſe varieties, in the late edition of his *Cryſtallographie.*

This ſalt melts with a mild heat, emitting abundance of aqueous vapours, at the ſame time that it ſwells up, and becomes converted into a very large light maſs, of an opaque white, with a great number of cavities. This phenomenon is produced, as in borax, by the diſengagement of water, whoſe vapour blows up and extends the ſaline maſs. The alum in this ſtate is called calcined alum, and weighs little more than half its former weight. It is ſomewhat altered; reddens the ſyrup of violets; has a ſtronger taſte; and appears to have its acid diſengaged. If it be diſſolved in water, a ſmall quantity of earth precipitates: it may be cryſtallized, but it ſcarcely ſwells at all on being calcined a ſecond time, as Baumé obſerves. If alum be calcined in an apparatus for diſtillation, water is obtained, which, towards the end, becomes acid; but it cannot be entirely decompoſed, ſince Geoffroy kept it in a retort in a fire of the utmoſt violence for three days and three nights, without producing any remarkable alteration. Yet there is reaſon to think, that the changes produceable in alum by a long continued heat have not yet been properly examined into.

Sulphat of alumine ſlowly effloreſces in the air, and loſes its water of cryſtallization. This ſalt is not very ſoluble in cold water, ſince two pounds of that fluid diſſolved no more than fourteen drachms of alum, according to Baumé; but boiling water diſſolves more than half its weight, eight ounces of water in this ſtate diſſolving five ounces of the ſalt. It cryſtallizes very well by cooling. Its cryſtals are triangular pyramids, with truncated angles. When they are depoſited on threads in the middle of the ſolution, very regular octahedrons are formed, whoſe pyramids are obliquely truncated at the middle, between the vertex and the baſe.

Silicious earth does not ſenſibly affect this ſalt. It may, however, be united to a much larger quantity of pure clay than it commonly contains. By this addition, its properties approach to thoſe of common clay, as Baumé has obſerved. To ſaturate alum with its earth, a ſolution of this ſalt muſt be boiled with very pure clay, and the mixture kept heated till it has loſt the ſtyptic taſte of alum. If the combination be well made, its taſte is inſipid, ſweetiſh, and earthy. Baumé obſerves, that by evaporation it affords leaves, or plates, reſembling mica. The Duc de Chaulne having expoſed for a long time to the air a lixivium of alum, ſaturated with its earth, found very regular cubical cryſtals at the end of ſome months. Mr. Le Blanc likewiſe obtained theſe cubical cryſtals at pleaſure. It is found that alum, ſaturated with its earth, cannot be eaſily reduced to its original ſtate of alum.

Sulphat of alumine is decompoſable by barytes and magneſia, which have a ſtronger affinity than alumine to the ſulphuric acid. Sulphat of barytes, or of magneſia, are produced in theſe decompoſitions.

Lime-water poured on a ſolution of this neutral ſalt precipitates its argillaceous baſe; fixed alkalis and ammoniac have likewiſe the property of decompoſing it. The carbonat of potaſh, ſoda, ammoniac, lime, and magneſia, likewiſe ſeparate the alumine which retains a portion of the carbonic acid, if the precipitation be made in the cold. But I have obſerved, that the mixture of a hot ſolution of alum, with hot ſolutions of alkaline carbonat, is attended with efferveſcence and diſengagement of carbonic acid.

Alumine, precipitated by theſe different ſubſtances very gradually, has the form of flocks. When gently dried, it is very white; and decrepitates or flies to pieces in the fire, like clays. A ſtrong heat gives it a very conſiderable degree of hardneſs, at the ſame time cauſing it to contract much in all its dimenſions. It is not fuſible in the ſtrongeſt heat, not excepting that of the focus of the lens of the garden De l'Infante. It retains the laſt portions of moiſture with ſuch force, as not to be deprived of it, but by the moſt violent heat. It may be formed into a paſte with water, which may be baked into porcelain of an excellent quality. Alumine has therefore all the characters of argillaceous earths, and is the pureſt clay which can be procured, as Macquer obſerves.

The effects of barytes, magneſia, lime, and pure alkalis, on alumine are not well known: it is probable that theſe ſubſtances, eſpecially the laſt, would convert it into a vitreous frit by fire. Mr. Achard has made a ſeries of experiments, which prove this aſſertion. The colour, tranſparency, hardneſs, and all the properties of this kind of glaſs vary according to the relative proportions of the ſubſtances which enter into its compoſition, as the diſſertation of that chemiſt ſhows.

The ſulphuric acid readily diſſolves alumine when moiſt, and newly obtained, but does not act with equal rapidity when it is dry. This ſolution in the quantity of many ounces affords cryſtals of alum, mixed with ſmall plates or ſcales, ſimilar to thoſe of mica. Baumé adds, that if this experiment be made in the ſmall way, the ſcaly ſubſtance only is obtained, and ſcarcely any alum; other acids likewiſe diſſolve this earth, and form ſalts little known, which we ſhall mention in the following articles.

The action of aluminous earth on neutral ſalts, has not been inquired into. But the moſt ſingular property it exhibits, is that of combining by exceſs to ſulphat of alumine, and of giving it new characters, as we have already obſerved. Baumé, the diſcoverer of this fact, boiled a ſolution of alum with the earth precipitated from another portion of alum, by means of fixed alkali; the earth was diſſolved with efferveſcence, the filtered ſolution had no longer the taſte of alum, but that of a hard water, did not redden the tincture of turnſole, but converted ſyrup of violets to a green. By ſpontaneous evaporation it afforded cryſtals, ſcaly and ſoft to the touch like mica. Baumé compares them to ſelenite, or ſulphat of lime; it is not eaſy to compoſe alum by adding ſulphuric acid to this ſaturated ſalt, the mixture becoming acid, but not ſtyptic. However, after ſpontaneous evaporation for three months, the ſolution afforded cryſtals of alum mixed with ſome micaceous ſcales, ſimilar to thoſe afforded by alum ſaturated with its earth. Theſe are the reſults of the experimental inquiry of Macquer and Baumé into the nature of aluminous earth [1].

Alum heated with combuſtible matters forms a ſubſtance which takes fire on expoſure to air, and is called the *phoſphorus of Homberg*. This chemiſt, who publiſhed an account of the Pyrophorus, in the year 1711, made experiments on human excrement for the purpoſe of obtaining a colourleſs oil poſſeſſing the property of fixing mercury into fine ſilver; the inquiry produced many diſcoveries; the reſidue of this animal ſubſtance diſtilled with alum, took fire on expoſure to the air. Homberg repeated this experiment a number of times, and always with ſucceſs. Lemery the younger, in the years 1714 and 1715, publiſhed two Memoirs, in which he affirms, that pyrophorus may be made with a great number of vegetable and animal ſubſtances heated with alum. But he did not ſucceed in his attempts to form it, with many other ſulphuric ſalts. Theſe two chemiſts, who ſuppoſed alum to be a combination of ſulphuric acid and calcareous earth, imagined that the latter being converted into lime attracted the humidity of the air, and that the ſulphur which they knew to be formed was inflamed by the heat produced in the mixture.

Since the time of theſe chemiſts, Le Jay de Savigny, Doctor of Medicine, has publiſhed excellent Memoirs concerning Pyrophorus, in the third volume of the *Memoires de Sçavans Etrangers*; wherein he deſcribes a great number of experiments by which pyrophorus was made, not only with alum and different combuſtible bodies, as Lemery has done, but likewiſe with moſt ſalts that contain the ſulphuric acid. This phyſician likewiſe propoſed a theory of the inflammation of pyrophorus expoſed to air, which has been univerſally received till very lately. He thinks that pyrophorus contains *glacial oil of vitriol*, which attracting the humidity of the air, and becoming ſtrongly heated, inflames the ſulphur, and produces the ſpontaneous inflammation.

Pyrophorus is uſually prepared by melting three parts of alum with one of ſugar, honey, or flour, in an iron ladle. The mixture is dried till it becomes blackiſh, and has ceaſed to ſmell. It is then pulverized, and put into a matraſs or phial ſtopped with earth, which is placed in a crucible filled with ſand. Heat is applied till a blueiſh flame appears to iſſue out of the neck of the phial. After this has continued ſeveral minutes, the crucible is taken out of the fire; and when the whole is cool, the pyrophorus is poured quickly into a dry bottle, which is immediately well cloſed. This pyrophorus, on expoſure to air, takes fire the more quickly in proportion as the air is more humid. The combuſtion is haſtened by any humid vapour, ſuch as that of the breath. If the pyrophorus be heated for two long a time, it will not take fire. When kept in an imperfectly cloſed veſſel, it gradually attracts humidity, and loſes its power of ſpontaneous inflammation; but this may be reſtored by calcining it again with the precautions before-mentioned.

Such was the ſtate of our knowledge before the Memoirs of Mr. Prouſt were publiſhed in the *Journal de Medicine*, for July 1778. This chemiſt having met with a great number of pyrophoric reſidues, in which the exiſtence of the ſulphuric acid could not be ſuſpected, concluded that the ſpontaneous inflammation of pyrophorus is not occaſioned by that acid. By a very ſimple experiment he ſhows, that it does not contain a particle of diſengaged ſulphuric acid, ſince he finds that the addition of water does not produce heat. From the enumeration of the different pyrophori which he obtained, it appears that all ſubſtances which after this decompoſition leave a carbonaceous reſidue, divided by an earth or metallic calx, are ſuſceptible of inflammation by expoſure to air. But it cannot be ſaid that any part of Mr. Prouſt's experiments, which he has yet communicated, point out the cauſe of the inflammation of Homberg's pyrophorus, which, according to him, differs from thoſe he has obſerved. His memoirs, in fact, teach us nothing concerning the ſubſtance we are treating of.

Mr. Bewly, an Engliſh ſurgeon, attributes the inflammation of pyrophorus to a ſubſtance capable of attracting the nitric acid of the atmoſphere. He adopted this opinion on diſcovering, that ſpirit of nitre immediately inflames pyrophorus which has not been ſufficiently calcined, or is loaded with moiſture. But on the one hand, it is not proved that the nitric acid exiſts ready formed in the atmoſphere; and, on the other hand, Mr. Prouſt has diſcovered that the inflammation of pyrophorus by the ſpirit of nitre ariſes from the carbon contained in the former, ſince that acid detonates with all dry carbonaceous matters in a ſtate of extreme diviſion, as we ſhall more amply explain at the article *Charcoal*. Mr. Bewly's theory does not therefore appear more ſatisfactory than that of the chemiſts who preceded him.

The cauſe of this phenomenon can only be diſcovered by an accurate inquiry into the chemical nature of Homberg's pyrophorus. It appears to contain earth of alum, carbonaceous matter in a ſtate of extreme diviſion afforded by the honey, ſugar, &c. a ſmall quantity of potaſh and ſulphur, partly united to the earth of alum, and partly to the alkali. When pyrophorus is ſtrongly heated in the pneumato-chemical apparatus, a large quantity of ſulphurated hydrogenous or *hepatic* gas is obtained; and when deprived of this, it is found to be no longer inflammable on expoſure to air. If pyrophorus be immerſed in a veſſel of vital air, it burns rapidly with a very brilliant red flame. By waſhing this ſubſtance in warm water, a true ſulphat is afforded, and carbonaceous matter with alumine are left on the filter: the pyrophorus is then decompoſed. Pyrophorus after combuſtion is found to be increaſed by the portion of oxygen it has abſorbed: it then affords ſulphat of alumine, becauſe the ſulphur burned by the action of the air forms ſulphuric acid, which unites to the aluminous earth; but this ſalt is found to be alum ſaturated with its earth.

The *Journal de Phyſique* for November 1780, contains obſervations on pyrophorus; in which it is affirmed, 1. That this ſubſtance owes its combuſtibility to a certain quantity of phoſphorus formed by the acid of mucilaginous matters. 2. That n ounce of pyrophorus, by diſtillation, affords from five to ſeven grains of phoſphorus. 3. That pyrophorus may be immediately formed by triturating in an iron mortar fifty-four grains of flowers of ſulphur, thirty-ſix of very dry charcoal of willow, and three of common phoſphorus. The particulars of this analyſis does not perfectly juſtify the concluſions; becauſe it does not ſhow that true phoſphorus was obtained. But the Memoir contains many intereſting facts which cannot but be uſeful to chemiſts, who propoſe to undertake a courſe of experiments on the nature of pyrophorus.

Alum is of very extenſive uſe in medicine; it is employed as an aſtringent, but it ought not to be internally adminiſtered without great precaution; it is moſt commonly applied externally as a powerful ſtyptic and deſiccative, with which intention it is uſed in the compoſition of plaſters, collyriums, &c.

Alum is one of the moſt uſeful ſalts in the arts. The makers of candles mix it with tallow to render that ſubſtance firm and hard. Printers rub their balls with calcined alum, that they may take the ink. Wood impregnated with a ſolution of alum is not burned without great difficulty, for which reaſon it has been propoſed as a means of ſecuring edifices from the effects of fire: it has the ſame effect on paper, which, however becomes yellow, and alters in a ſhort time.

Bleachers throw a ſmall quantity of alum into water, to render it clear. Baumé ſuppoſes that the ſalt becomes charged with a portion of the earth ſuſpended in that fluid, and forms an inſoluble compound, which precipitates. Some uſe this method of rendering water clear for drinking. It is alſo uſed in the preparation of ſkins, and to impregnate paper and cloths, which are intended to be printed.

A ſolution of alum retards the putrefaction of animal ſubſtances, and affords a very uſeful as well as economical means of preſerving the natural productions imported from foreign countries. Earth of alum is the body or ſolid matter of paſtils or crayons. Laſtly, It is the ſoul of the art of dyeing, as Macquer calls it; it augments the intenſity and brilliancy of colours, and gives ſolidity to colouring extractive matters, which would elſe be periſhable, and eaſily diſcharged by water. This laſt mentioned action of alum on vegetable colouring matters ſhall be examined in the hiſtory of thoſe ſubſtances; where it will be ſeen that alum gives them ſolidity, by changing their nature, decompoſing them, and rendering them inſoluble in water.

Species II. Aluminous Nitrat.

Baumé affirms that the nitric acid completely diſſolves the earth of alum. This ſolution is limpid, and much more aſtringent than that of alum. By ſpontaneous evaporation it affords ſmall pyramidal cryſtals very ſtyptic and deliqueſcent. The other properties of this ſalt have not yet been examined; and it is only known, that the ſame intermediums decompoſe this ſalt and alum. It has not yet been found in nature, but is always produced by art.

Species III. Aluminous Muriat.

The muriatic acid diſſolves aluminous earth more readily than the nitric acid. This ſaturated ſolution is gelatinous, and cannot be filtered without dilution in a large quantity of water. Its taſte is ſaline and ſtyptic; it reddens ſyrop of violets, and afterwards converts them to a green. By ſpontaneous evaporation it affords very ſtyptic cryſtals, whoſe form has not been examined. Lime-water decompoſes it. It is deliqueſcent, and is always produced by art; its other properties have not yet been diſcovered.

Species IV. Aluminous Borat.

The combination of boracic acid with the earth of alum, which we call aluminous borat, has not yet been obſerved. It is only known, that if a ſolution of borat of ſoda be added to a ſolution of aluminous ſulphat, a light and fleecy precipitate is formed. The ſulphuric acid quits the alumine to unite with the ſoda. This earth combines with the boracic acid, which is at the ſame time ſeparated, and the new ſalt is gradually rediſſolved. The liquid precipitated by fixed alkali, affords by evaporation, a viſcid and aſtringent maſs, in which ſulphat of ſoda and aluminous borat are confounded together. This ſpecies of borat is decompoſable by the ſame ſubſtances as alum: its properties have not yet been examined with ſufficient care.

Species V. Aluminous Fluat.

By this name we indicate the combination of fluoric acid with alumine. This neutral ſalt is not known. Scheele, Boulanger, and Bergman, ſay nothing of this combination.

Species VI. Aluminous Carbonat.

Though the union of the carbonic acid with clay has been hitherto ſcarcely examined, yet it it is certain that a portion of this acid combines with aluminous earth ; becauſe, 1. According to the remark of Bergman, when a ſolution of alum is precipitated by the alkaline carbonats, the filtered liquor depoſits, at the end of a certain time, a ſmall quantity of earth, which was held in ſolution by the carbonic acid, and is ſeparated in proportion as that acid flies off. 2. This precipitation, when made in the cold, is not attended with effervеſcence, and a portion of the carbonic acid ſeparated from the alkali, appears to combine with the alumine, while another portion becomes diſſolved in the fluid.

It is likewiſe acknowledged, from the analyſis of many argillaceous earths, by modern chemiſts, that they contain the carbonic acid ; for they effervеſce, when diſſolved in the ſulphuric or muriatic acids.

CHAPTER X.

Genus VI. Neutral salts with base of barytes.

Barytes forms, with acids, neutral ſalts different from all ſuch as we have hitherto examined, not only in their form, taſte, and ſolubility, but likewiſe in the laws of their decompoſition. The earthy alkaline baſe, which conſtitutes them, has a ſtronger affinity than the three alkalis and the other earths with acids. It is therefore neceſſary that theſe alkaline ſubſtances ſhould be united with the carbonic acid, in order to ſeparate this baſe, and decompoſe barytical ſalts. Theſe ſalts are ſix in number ; namely, barytical ſulphat, or ponderous ſpar, barytic nitrat, barytic muriat, barytic borat, barytic fluat, and barytic carbonat. To theſe ſix ſalts muſt be added the combinations of barytes, with the tungſtenic, arſenical, molybdic, and ſuccinic acids ; but theſe being much leſs known, will be treated of in the hiſtory of theſe four acids.

Species I. Barytic Sulphat, or Ponderous Spar.

Ponderous ſpar, hitherto conſidered as a ſtone, becauſe it has neither taſte nor ſolubility, is the reſult of a combination of the ſulphuric acid with barytes : it ought to be named *barytic ſul-*

phat. This earthy ſalt has hitherto been confounded with *fluor ſpar*, or calcareous fluat, by many naturaliſts, and in fact it breaks in the ſame manner, and does not effervesce with acids; but its form, its imperfect tranſparency, and eſpecially its great weight, are ſufficient to diſtinguiſh it. A ſingle chemical character likewiſe anſwers this purpoſe; for if a ſmall quantity of ſulphuric acid be poured on this ſpar reduced to powder, no vapour of any kind is diſengaged, nor ſmell perceived; whereas the calcareous fluat, or *fluor ſpar*, if treated in the ſame manner, gradually emits a penetrating vapour, which forms a white ſmoke when it comes into contact with air, and is eaſily known to be the fluoric acid. Other naturaliſts have confounded it with ſome varieties of *ſelenite*, or ſulphat of lime; but this laſt has neither the ſame form, nor the ſame inſolubility, and is decompoſed by pure or cauſtic fixed alkalis; whereas ponderous ſpar is not altered by thoſe ſalts.

Barytic ſulphat is found in large quantities. It moſt commonly accompanies metallic ores; it is either cryſtallized, or in irregular maſſes, but is always diſpoſed in layers of various thickneſs and extent. Its hardneſs is conſiderable, though it does not give fire with ſteel. Its principal varieties are the following:

Varieties.

1. Barytic ſulphat, or white *ponderous ſpar*, ſemi-tranſparent, cryſtallized in ſix-ſided priſms, two ſides very large, four very ſmall, terminated by dihedral ſummits. Theſe cryſtals are obliquely placed on maſſes of the ſame nature; they reſemble long ſquare plates, whoſe four ſides have been cut diamond-ways. They are often covered with rhomboidal yellow cryſtals. This ſpecimen, as well as the following, is called *ponderous ſpar in tables:*
2. Barytic ſulphat, or *ponderous ſpar*, of a milky white, in tables, without chamfered edges. It is not regularly cryſtallized, but is formed of thick layers placed on each other; it is often incruſted with a red powder of ſilver ore, or *pyrites.*
3. Barytic ſulphat, or *ponderous ſpar* rounded, and ſemi-chatoyant. Bologna ſtone. It is compoſed of many converg-

ing fibres, which unite into laminæ, applied on each other. This variety is the moſt known on account of its phoſphoric property, it has evidently been worn round by water.

4. Barytic ſulphat, or octahedral *ponderous ſpar;* the ſummits of the pyramids are often truncated, which form a decahedron. The length of its ſides, or the truncature of its angles, likewiſe exhibits other varieties.
5. Barytic ſulphat, or dodecahedral *ponderous ſpar;* it has the form of ſome garnets and pyrites, and is more rare than the former.
6. Barytic ſulphat, or pyramidal *ponderous ſpar.* This variety, as well as the foregoing, is indicated in Daubenton's table.

I have conſidered as a variety of *ponderous ſpar*, the ſpar called *pearly* (*perlé*) which was formerly claſſed, like moſt of the foregoing, among the ſelenites. This ſpar is formed of ſmall rhomboidal plates, uſually brilliant, and placed obliquely one over the other. It is opaque, brilliant, as it were micaceous, and ſprinkled on calcareous ſpar, or quartz, or on the firſt variety we have deſcribed. It is of a yellow or dirty green colour, and ſometimes of a ſilvery white. According to the Abbé Hauy, it is a true *calcareous ſpar.*

Margraaf, who examined many varieties of barytic ſulphat, ſuch as the Bologna ſtone, and white opaque ponderous ſpar, ſuppoſed it to be a true *ſelenite* or calcareous ſulphat, mixed with a ſmall quantity of clay, which rendered it inſoluble; but Gahn, Scheele, and Bergman, find that it contains a peculiar earth, which we have diſtinguiſhed by the name of *barytes.* Monnet likewiſe found, that its baſe differs from calcareous earth, by the ſalts it forms with acids; but that chemiſt admits it to contain ſulphur ready formed, and conſiders *ponderous ſpar* as an earthy *liver of ſulphur* in a cryſtallized ſtate.

Barytic ſulphat melts by a violent heat, ſuch as that of the porcelain furnace, &c. and affords a coloured glaſs. A low heat does not at all change it. If it be taken into the dark, after it has been heated rather ſtrongly, it exhibits a vivid blueiſh light. Lemery reports, that an Italian ſhoemaker, named Vincenzo Caſciarolo, firſt diſcovered the phoſphoric property of the Bologna ſtone. This man found it at the foot of Mount Paterno, and from its brilliancy and weight was led to ſuppoſe that it contained ſilver. Having expoſed it to the fire, doubtleſs with the intention of diſcovering that precious metal, he obſerved that it was luminous in the dark; a diſcovery which engaged his attention, and was frequently repeated with ſucceſs. Many philoſophers and chemiſts have ſince examined this phenomenon, and have varied the method of calcining the Bologna ſtone in many reſpects. The works of La Poterie, Montalban, Mentzel, Lemery, Homberg, Dufay, and Margraaf, contain many proceſſes of this nature.

It is now known that this property is common to all the varieties of barytic ſulphat. The proceſs conſiſts in heating them red hot in a crucible, reducing them to powder in a glaſs mortar, and forming the ſame into a paſte, with a ſmall quantity of mucilage of gum tragacanth, in pieces of the thickneſs of the blade of a knife. Theſe being dried, are ſtrongly calcined by placing them in the middle of the coals of a furnace which draws well. When the coal is all conſumed, and the furnace grown cold, the pieces are cleanſed from the aſhes by means of a bellows. If theſe be expoſed to the light for a few minutes, and afterwards carried into an obſcure place, they ſhine like a burning coal. They even ſhine when immerſed in water. They loſe this property by degrees, but recover it on being again heated. Many other ſubſtances likewiſe exhibit this appearance. Magneſia, chalk, calcareous ſulphat and fluat, &c. become luminous after having been heated. Macquer obſerved the ſame property in earth of alum, ſulphat of potaſh, Briançon chalk, black flint calcined, which proves, that the preſence of an acid is not abſolutely neceſſary for the production of this phenomenon, though it ſeems in ſome reſpect to contribute to its intenſity.

Barytic ſulphat, heated in a retort, afforded no product, and was not at all altered by the operation, as Margraaf affirms.

This ſalt is perfectly inſoluble in water, and is not acted on by earths or ſalino-terreſtrial ſubſtances. Pure fixed alkalis do not decompoſe it. This laſt is one of its moſt ſingular properties. In fact, the other earthy and ſalino-terreſtrial ſubſtances have leſs affinity than fixed alkalis to the ſulphuric acid; but barytes, on the contrary, has more. Whence we have obſerved, after Bergman, that this earth decompoſes the ſulphats of potaſh and ſoda, as it does likewiſe ſalt containing ammoniac.

Mineral acids have no action on ſulphat of barytes, becauſe the ſulphuric acid adheres more ſtrongly than any other to the earth, which forms the baſe of this ſalt. Neither do neutral ſalts produce any change in it, if we except the carbonats of potaſh and ſoda, which produce a decompoſition by double affinity. The barytes is ſeparated from the ſulphuric acid, becauſe it is attacked by the carbonic acid, at the ſame time that one of the alkalis ſeizes the former acid. To produce this decompoſition, a mixture of two parts of carbonat of potaſh, and one part of ſulphat of barytes reduced to powder, are ſtrongly heated in a crucible. The matter which is ſemi-vitrified is to be waſhed in diſtilled water; and the liquid, after filtration and evaporation, affords ſulphat of potaſh: the ſubſtance which remains on the filtre is carbonat of barytes; which, when well waſhed, is in the form of a very white and fine pulverulent matter, but uſually impure, becauſe it always contains a portion of ſulphat of barytes, which has eſcaped the decompoſition.

Combuſtible ſubſtances having the property of decompoſin this earthy ſalt, may likewiſe be employed to obtain its baſe. When pulverized ſpar is expoſed to a red heat in a crucible for two or three hours, together with one eighth of its weight of charcoal in powder, if the matter be poured into diſtilled water, it immediately communicates a yellow colour to the fluid, together with every other character of a ſolution of an earthy ſulphure. The charcoal having deprived the ſulphuric acid of its oxygen, the ſulphur, ſet at liberty by this decompoſition, unites to the barytes, which reduces it to the ſtate of a ſulphure or hepar. The ſulphur is precipitated from this ſolution by means of an acid. The muriatic acid is preferred, becauſe it forms with ponderous earth a ſoluble ſalt, whereas the ſulphuric acid would re-compoſe the inſoluble ſulphat of barytes. The liquid is then filtered, and the ſulphur ſeparated. The muriat of barytes contained therein is decompoſed by a ſolution of carbonat of potaſh; and the barytes combining with the carbonic acid, is precipitated. The latter may be ſeparated by calcination. This proceſs, which I have performed a great number of times, affords but a very ſmall quantity of barytes; and the quantity of ſulphur on the filter, precipitated from the hepar by the muriatic acid, is likewiſe very inconſiderable, unleſs the ponderous ſpar has been ſtrongly heated. To accelerate the decompoſition of this earthy ſalt, Bergman and Scheele have recommended the addition of about one-fourth of *fixed ſalt of tartar*, to the mixture of ſulphat of barytes and coal. By this means the fuſion is rendered much more complete, and the ſulphur and barytic earth are more eaſily ſeparated.

From theſe proceſſes for the decompoſition of ſulphat of barytes, as well as from every other property of this ſalt, it is evident how much the earth, or ſalino-terreſtrial ſubſtance, which conſtitutes its baſe, differs from other earthy ſubſtances, namely, clay, lime, and magneſia.

Sulphat of barytes is not applied to any uſe *. Phoſphoric cakes are prepared of this ſubſtance, and the ponderous earth is extracted for chemical experiments.

Species II. Nitrat of Barytes.

The nitric acid readily unites with barytes, and produces a neutral ſalt, in large hexagonal cryſtals, or ſmall irregular ones, according to Mr. D'Arcet. It is not obtained in the cryſtalline form without conſiderable difficulty.

Barytic nitrat is decompoſed by fire, and affords vital air.

It attracts the moiſture of the air, and nevertheleſs requires a conſiderable quantity of water to hold it in ſolution.

Neither pure alkalis, nor ſand, alumine, lime, or magneſia, decompoſe it.

The ſulphuric acid, poured on a ſolution of barytic nitrat, immediately precipitates ſulphat of barytes; the fluoric acid likewiſe ſeizes its baſe.

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* Dr. Withering, in the Philoſophical Tranſactions for 1784, Part II. points out a valuable chemical purpoſe, to which the barytic muriat may be applied; namely, the purification of the marine acid from the admixture of ſulphuric acid, by which it is often adulterated. The ſolution of this ſalt cauſes the ſulphuric acid to fall to the bottom, together with the earth, in the form of ponderous ſpar.

Alkaline carbonats decompoſe it by double affinity.

This ſalt is hitherto very little known.

Species III. Muriat of Barytes.

This ſalt has not been more examined than the foregoing. Bergman affirms, that it is cryſtallizable, and of difficult ſolution; its cryſtals are ſquare and long, much reſembling *ponderous ſpar* in tables.

Silex, alumine, lime, magneſia, or pure alkalis, have no action on this ſalt, and do not precipitate its principles.

The ſulphuric and fluoric acids decompoſe this ſalt by combining with its baſe.

The carbonats of potaſh and ſoda precipitate the barytes combined with the carbonic acid.

Bergman reckons muriat of barytes among the moſt ſenſible re-agents, and propoſes it for detecting the ſmalleſt poſſible quantity of ſulphuric acid contained in any mineral water. One or two drops of a ſolution of this ſalt poured into about three pounds of water, containing twelve grains of cryſtals of ſulphat of ſoda, immediately produce white ſtriæ of ſulphat of barytes, formed by the double decompoſition of theſe two ſalts, and by the union of the ſulphuric acid with the barytes, the muriat of ſoda remains diſſolved in the liquid. All ſulphuric ſalts are equally affected by this re-agent, which decompoſes them, and affords ſulphat of barytes.

Species IV. Barytic Borat.

The combination of boracic acid with barytes is not at all known.

Bergman affirms that the acid of borax is one of thoſe which has the leaſt affinity with this ſalino-terreſtrial ſubſtance, and places it in his table below moſt of the vegetable and animal acids.

Species V. Barytic Fluat.

This ſalt is not more known than the foregoing, and, with many other ſaline ſubſtances not yet examined, affords matter for experimental inquiry.

Bergman, in his diſſertation on Elective Attractions, affirms, that the fluoric acid poured on a ſolution of nitrat, or muriat of barytes, occaſions a precipitate; and that this precipitate effervеſces with the ſulphuric acid, which diſengages the fluoric acid.

This experiment proves, that the fluoric acid has a ſtronger affinity than the nitric and muriatic acids with barytes, and that it forms with this ſalino-terreſtrial ſubſtance a ſalt much leſs ſoluble than barytic nitrat or muriat.

Species VI. Carbonat of Barytes.

Barytes is capable of uniting with the carbonic acid, and forms a kind of neutral ſalt poſſeſſed of peculiar properties, and which ſeems in ſome reſpects to reſemble clay.

It has already been obſerved, that ſulphat of barytes, and all the ſalts of which this earth is the baſe, are decompoſed by alkaline carbonats, by virtue of the affinity of barytes with the carbonic acid. In theſe decompoſitions, barytic carbonat is precipitated. This ſpecies of ſalt is likewiſe obtained by expoſing a ſolution of this pure ſalino-terreſtrial ſubſtance to the air. The ſurface becomes ſlowly covered with a pellicle, which effervеſces with acids; a phenomenon which ariſes from the carbonic acid of the atmoſphere combining with the earth, and rendering it leſs ſoluble; in the ſame manner as lime is ſeparated from lime-water. This fact exhibits a ſtriking analogy between theſe two ſalino-terreſtrial ſubſtances, which differ ſo much from each other in many other reſpects.

Barytic carbonat, when expoſed to heat, loſes its acid. If it be heated in a retort, or in a matraſs, to which a pneumato-chemical apparatus is adapted, the acid is obtained in its natural or gaſeous form. The laſt portions are not ſeparated without great difficulty, and by an extreme heat.

All the mineral acids decompoſe this ſalt, and diſengage the carbonic acid, with a ſtrong efferveſcence, which diſtinguiſhes it from pure barytes. Bergman eſtimates that this ſalt contains in the hundred, ſeven parts of carbonic acid, ſixty-five of barytes, and eight of water.

Water does not diſſolve carbonat of barytes in any ſenſible quantity; but when the fluid itſelf is ſaturated with carbonic acid, it diſſolves about the 1550th of its weight. Hence we may perceive, that carbonat of barytes is leſs ſoluble in water, than when pure or cauſtic, ſince in the laſt mentioned ſtate about the 900th part is taken up according to Bergman. In this reſpect, therefore, it reſembles carbonat of lime; from which, nevertheleſs, it differs in a great number of other properties, particularly in the ſalts which it forms with acids, as we have already ſeen in the examination of theſe ſalts.

Carbonat of barytes is not applied to any uſe *.

CHAPTER XI.

RECAPITULATION OF FACTS, AND COMPARISON OF THE MINERAL SALTS WITH EACH OTHER.

After having exhibited the ſtate of our knowledge, as far as it reſpects the properties of all the known mineral ſalts, we think it neceſſary to give a ſhort account of their leading characters, properties and mutual attractions.

I. Salts are diſtinguiſhed by four general properties; taſte, tendency to combination, ſolubility, and incombuſtibility. Theſe properties have very different degrees of energy, and theſe degrees conſtitute the moſt eſſential differences that exiſt between them.

II. All ſalts may be reduced to four orders or principal genera. 1. The ſalino-terreſtrial ſubſtances, which unite the earthy to the ſaline properties. 2. Alkalis, which have an urinous taſte, and change the colour of many vegetables from blue to green. 3. Acids known by their ſour taſte, and the red colour they produce with blue vegetable ſubſtances. 4. Mean, or neutral ſalts, which differ from the foregoing by their weaker

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* Dr. Withering, in his valuable paper on the Native Carbonat (Phil. Tranſ. for 1784), obſerves, (1) That it reſembles a lump of alum, but is compoſed of ſpiculæ. (2) That its ſpecific gravity is from 4,300 to 4,338. (3) That 100 parts contain 78,6 parts of pure barytic earth, 6 ſulphat of barytes, and 20,8 of carbonic acid. (4) That it will not burn to lime, as the artificial carbonat of barytes does; but when urged by heat, becomes firſt opaque, and afterwards melts; a peculiarity, which the Doctor thinks, ariſes from water not being preſent. The many other curious and intereſting facts contained in the Diſſertation, cannot be abridged into a note, but they are well worthy the reader's attention. T.

taſte, which is mixed, bitter, &c. leſs degree of ſolubility, &c.

III. There are three ſalino-terreſtrial ſubſtances; ponderous earth or barytes, magneſia, and lime. Their properties are known, but not their compoſition. No chemiſt has yet ſucceeded in ſeparating their component parts, and forming them again by combination. They are therefore ſimple or elementary ſubſtances, with reſpect to the preſent ſtate of ſcience, though we may perhaps ſucceed hereafter in our attempts to decompoſe them.

IV. Three alkaline ſalts are known; potaſh, called alſo *fixed vegetable alkali*, *ſalt of tartar;* ſoda, called alſo *the mineral alkali*, or *marine alkali;* and ammoniac, or the *volatile alkali*. The two firſt are dry, ſolid, cauſtic, fuſible, deliqueſcent, &c. not diſtinguiſhable from each other when pure, but eaſily known by their combinations. No experiment has yet ſhown their intimate compoſition; their principles have not been ſeparated, neither have they yet been formed by any combination.

That opinion which regards alkalis as an union of water and earth, is merely an ingenious hypotheſis, which cannot be maintained, becauſe ſupported by no plauſible fact. Ammoniac differs from the two foregoing, becauſe it exiſts in the form of an elaſtic fluid of a very penetrating ſmell, &c. It is at preſent more than ſuſpected, that it is a compound of two gaſes, inflammable gas or hydrogen and atmoſpheric *mephitis* or azot; that it is decompoſed in many operations, and formed again in others. It would appear that the two fixed alkalis alſo contain azot, and that this ſubſtance may be conſidered as the alkalifiant principle, or as *alkaligine*.

V. The well known acids are ſix in number; the carbonic, the muriatic, the fluoric, the nitric, the ſulphuric, and the boracic. All have peculiar and diſtinctive properties. The carbonic, muriatic, and fluoric acids, aſſume the elaſtic or aeriform ſtate very readily; the ſulphuric and nitric acids do not aſſume it with equal facility; the boracic acid is concrete and cryſtalline. The arſenic, molybdic, and tungſtenic acids which we ſhall treat of in a ſupplementary chapter, are concrete, but pulverulent, and without a regular cryſtalline form.

VI. We begin to be acquainted much better than formerly with the nature of acids. It is proved, that the hypotheſis, which conſidered them as an intimate union of water and earth, is no longer probable. It is demonſtrated, that the baſe of vital air or oxygen enters into their compoſition; that this oxygen is often united with a combuſtible body, as charcoal in the carbonic acid, ſulphur in the ſulphuric acid, azot in the nitric acid. The formation of a great number of peculiar acids by the action of the nitric acid on combuſtible bodies, confirms this aſſertion reſpecting the neceſſity of oxygen to conſtitute acids.

VII. Acids unite, without decompoſition, with alumine, barytes, magneſia, lime, the fixed alkalis and ammoniac. From theſe combinations reſult a great number of ſalts, called *compound, middle, or neutral ſalts.* Subſtances, which neutralize acids in ſaline compounds, are called baſes.

VIII. Middle, or neutral ſalts, have properties which differ from thoſe of their component parts. In moſt of them, we cannot diſtinguiſh the character either of the acid or baſe. The latter, however, rather than the acid, appears to communicate certain general properties to neutral ſalts; for which reaſon we have diſtinguiſhed neutral ſalts by their baſes.

IX. On this principle there are ſix genera of neutral ſalts, whoſe order, compoſition, and nomenclature, are as follow.

GENUS I. Neutral Salts, with a baſe of Fixed Alkali.

Species.	Ancient Names.
I. The ſulphuric acid with potaſh. SULPHAT OF POTASH.	*Vitriolated tartar, ſal de duobus, arcanum duplicatum, vitriol of potaſh.*
II. The ſulphuric acid with ſoda. SULPHAT OF SODA.	*Glauber ſalt, vitriol of ſoda.*
III. The nitric acid with potaſh. NITRAT OF POTASH.	*Common nitre, ſaltpetre.*
IV. The nitric acid with ſoda. NITRAT OF SODA.	*Cubic nitre, rhomboidal nitre.*

Species.	Ancient Names.
V. The muriatic acid with potaſh. MURIAT OF POTASH.	*Digeſtive ſalt, febrifuge of ſalt Sylvius, regenerated marine ſalt.*
VI. The muriatic acid with ſoda. MURIAT OF SODA.	*Marine ſalt, ſea ſalt, common ſalt, kitchen ſalt.*
VII. The boracic acid with potaſh. BORAT OF POTASH.	*Vegetable borax.*
VIII. The boracic acid with ſoda. SUPERSATURATED BORAT OF SODA, *or* BORAX.	*Common borax, tinckal.*
IX. The fluoric acid with potaſh. FLUAT OF POTASH.	*Spathoſe tartar.* *Spar of tartar.*
X. The fluoric acid with ſoda. FLUAT OF SODA.	*Sparry ſoda.*
XI. The carbonic acid with potaſh. CARBONAT OF POTASH.	*Cretaceous tartar.* *Chalk of potaſh.*
XII. The carbonic acid with ſoda. CARBONAT OF SODA.	*Cretaceous ſoda.* *Chalk of ſoda.*

GENUS II. Ammoniacal Neutral Salts.

Species.	Ancient Names.
I. The ſulphuric acid with ammoniac. AMMONIACAL SULPHAT.	*Glauber's ſecret ammoniacal ſalt, ammoniacal vitriol.*
II. The nitric acid with ammoniac. AMMONIACAL NITRAT.	*Ammoniacal nitre.*

Species.	Ancient Names.
III. The muriat acid with ammoniac. AMMONIACAL MURIAT.	*Sal ammoniac.*
IV. The fluoric acid with ammoniac. AMMONIACAL FLUAT.	
V. The boracic acid with ammoniac. AMMONIACAL BORAT.	
VI. The carbonic acid with ammoniac. AMMONIACAL CARBONAT.	*Engliſh ſal volatile.* *Concrete volatile alkali.* *Ammoniacal chalk.*

GENUS III. Calcareous Neutral Salts.

Species.	Ancient Names.
I. The ſulphuric acid with lime. CALCAREOUS SULPHAT.	*Plaſter.* *Gypſum.* *Selenite.* *Calcareous vitriol.*
II. The nitric acid with lime. CALCAREOUS NITRAT.	*Calcareous nitre.*
III. The muriatic acid with lime. CALCAREOUS MURIAT.	*Fixed ſal ammoniac, oil of lime.* *Calcareous marine ſalt.*
IV. The fluoric acid with lime. CALCAREOUS FLUAT.	*Cubic ſpar, vitreous ſpar, fuſible ſpar or fluor, ſparry fluor, fluorated lime.*
V. The boracic acid with lime. CALCAREOUS BORAT.	

Species.	Ancient Names.
VI. The carbonic acid with lime.	
CARBONAT OF LIME.	*Chalk, calcareous ſpar, calcareous earth.*

GENUS IV. Magneſian Neutral Salts.

Species.	Ancient Names.
I. The ſulphuric acid with magneſia.	
MAGNESIAN SULPHAT.	*Salt of Epſom or Sedlitz, bitter cathartic ſalt, vitriol of magneſia.*
II. The nitric acid with magneſia.	
MAGNESIAN NITRAT.	
III. The muriatic acid with magneſia.	
MAGNESIAN MURIAT.	*Marine ſalt, with a baſe of magneſia.*
IV. The fluoric acid with magneſia.	
MAGNESIAN FLUAT.	
V. The boracic acid with magneſia.	
MAGNESIAN BORAT.	
VI. The carbonic acid with magneſia.	
MAGNESIAN CARBONAT.	*Efferveſcent magneſia.* *Mild, aerated magneſia.* *Magneſian chalk.*

GENUS V. Aluminous Neutral Salts.

Species.	Ancient Names.
I. The ſulphuric acid with aluminous earth.	
ALUMINOUS SULPAAT.	*Alum, vitriol of clay.*

Species.	Ancient Names.
II. The nitric acid with aluminous earth.	
ALUMINOUS NITRAT.	*Argillaceous nitre.* *Nitreous alum.*
III. The muriatic acid with aluminous earth.	
ALUMINOUS MURIAT.	*Argillaceous marine ſalt.* *Marine alum.*
IV. The fluoric acid with aluminous earth.	
ALUMINOUS FLUAT.	*Sparry clay.* *Argillaceous fluor.*
V. The boracic acid with aluminous earth.	
ALUMINOUS BORAT.	*Argillaceous borax.*
VI. The carbonic acid with aluminous earth.	
ALUMINOUS CARBONAT.	*Efferveſcent clay.* *Argillaceous chalk.*

GENUS VI. Neutral Salts, with a Baſe of Barytes, or Barytic Neutral Salts.

Species.	Ancient Names.
I. The ſulphuric acid with barytes.	
BARYTIC SULPHAT.	*Ponderous ſpar.* *Barotic vitriol.*
II. The nitric acid with barytes.	
BARYTIC NITRAT.	*Ponderous nitre.* *Barotic nitre.*
III. The muriatic acid with barytes.	
BARYTIC MURIAT.	*Ponderous marine ſalt.*

Species.	Ancient Names.
IV. The fluoric acid with barytes. BARYTIC FLUAT.	
V. The boracic acid with barytes. BARYTIC BORAT.	
VI. The carbonic acid with barytes. BARYTIC CARBONAT.	*Aerated ponderous earth.* *Cretaceous ponderous earth.* *Barotic chalk.*

X. To theſe ſalts may be joined ſuch as are formed by the arſenic, molybdic, tungſtenic, and ſuccinic acids; the former of which may be diſtinguiſhed by the terms *arſeniats of potaſh, ſoda,* &c. the ſecond, *molybdats of potaſh, of ſoda, of ammoniac, and lime;* the third, *tungstat of potaſh, of ſoda, of lime,* &c.; and the fourth, *ſuccinats of potaſh, of magneſia, alumine,* &c. We ſhall treat of theſe four genera of neutral ſalts in the hiſtory of metallic and bituminous ſubſtances.

XI. Each peculiar ſalt, whether it be ſimple or compound, poſſeſſes diſtinguiſhing characters, by which it may be known from every other. Theſe characters conſiſt in their taſte, their figure, and their habitudes, with reſpect to fire, air, the earths, and ſalts. They cannot be well diſtinguiſhed, but by a careful attention to all their properties, by comparing them with each other, and eſpecially by attending to ſuch properties as are the moſt peculiar.

XII. Though moſt of the ſimple ſalts in common uſe, more eſpecially the neutral, are produced by art, yet nature offers them in large quantities, either at the ſurface, or at ſmall depths in the earth. Neither pure barytes, nor magneſia, have yet been found. Quick-lime exiſts in the neighbourhood of volcanos. Fixed alkalis are never cauſtic at the ſurface of the earth, but are combined with acids. The carbonic acid is contained in the atmoſphere, fills ſeveral ſubterraneous cavities, and is diſengaged from many waters. The muriatic acid appears to be at liberty at the ſurface of the ſea. The fluoric acid is always found combined with lime. The nitric acid is found amongſt putrified matters. The ſulphuric acid has been found cryſtallized, by Mr. Baldoſtari, in a grotto at the baths of St. Philip in Italy; and by Dolomieu, in a grotto near Mount Ætna. Mr. Vandelli has alſo obſerved, in the neighbourhood of Sienna and Viterbo, the ſulphuric acid diſſolved in water iſſuing from amongſt rocks. The ſulphurous acid is continually diſengaged in volcanic places. The boracic acid is diſſolved in the water of many of the lakes in Tuſcany, according to Mr. Hoefer.

XIII. Among the forty-two ſpecies of neutral ſalts *, the following only have been found at the ſurface of the globe, in the waters, or among the fluids of organized bodies, in the genus of perfect neutral ſalts, with baſe of fixed alkali: ſulphat of potaſh in vegetables; ſulphat of ſoda, diſſolved in water, and exiſting in certain plants; nitre in the juices of vegetables, and in earths impregnated with putrid matters; muriat of potaſh in water and marine plants; muriat of ſoda in earth, water, ſea plants, and animal fluids; carbonat of potaſh in vegetables; carbonat of ſoda in efloreſcence, on the ſurface of the earth, on ſtones, and in the animal fluids. It is not well determined whether borax is ever found native †. Nitrat of ſoda, fluat of potaſh, fluat of ſoda, and borat of potaſh, are always produced by art.

XIV. Among the ammoniacal ſalts, none are found in nature, excepting muriat of ammoniac, in the neighbourhood of volcanos, and carbonat of ammoniac in putrified animal matters. Sulphat of ammoniac, nitrat of ammoniac, fluat of ammoniac, and borat of ammoniac, are always produced by art.

XV. Neutral calcareous ſalts are abundantly found, there being but one of the ſix ſpecies we know, which is not produced in nature. Calcareous ſulphat, or ſelenite, forms conſider-

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* I do not here ſpeak of the modifications of theſe ſalts, called ſulphits, nitrits, oxygenated muriats, &c. nor of the twenty-eight ſpecies formed by the metallic and bituminous ſalts, which would make the number of neutral ſalts much more conſiderable; beſides which, theſe ſalts do not appear to exiſt in nature.

† Mr. Grill Abrahamſon ſent ſome borax to Sweden, in the year 1772, in a cryſtalline form, as dug out of the earth, in the kingdom of Thibet, where it is called pounxa, my poun, and houi poun. *Kirwan's Mineralogy*, page 206. T.

able beds in mountains: carbonat of lime, or calcareous ſubſtances, conſtitute a great part of the external cruſt of the earth: calcareous nitrat conſtantly accompanies common nitre in the places where it is produced; calcareous muriat is likewiſe conſtantly found to accompany muriat of ſoda. Calcareous fluat is abundantly found in mines.

XVI. Magneſian ſalts are much more rarely found in nature, ſulphat and muriat of magneſia being only found diſſolved in certain waters. Magneſian nitrat likewiſe exiſts but in very ſmall quantities. Nature has not yet been found to afford magneſian borat, magneſian fluat, and magneſian carbonat; the latter, however, appears to exiſt, or is combined, in many ſtones.

XVII. Among the ſix barytic neutral ſalts, ſulphat of barytes is the only one met with; it is found in the clefts of mountains, and always in the vicinity of mines. Barytic nitrat, muriat, borat, and fluat, have not yet been diſcovered in a natural ſtate.

The carbonat of barytes has been diſcovered ſome years ago in England perfectly cryſtallized, and in large maſſes.

XVIII. Aluminous ſalts are nearly as ſcarce; ſulphat of alumine is almoſt the only ſalt of this genus which is found ready formed. It exiſts in volcanos, and volcanized earths; in efflореſcence, on decompoſed lavas; and is alſo contained in pyrites which have fallen into eﬄoreſcence. Aluminous nitrat, muriat, borat, and fluat, are mere artificial products: alumine is frequently combined with carbonic acid, there not being any earth of this ſpecies from which that acid may not be ſeparated by the application of a ſtronger.

CHAPTER XII.

AN EXAMINATION OF CERTAIN GENERAL PROPERTIES OF SALTS, PARTICULARLY THEIR CRYSTALLIZATION, FUSIBILITY, EFFLORESCENCE, OR DELIQUESCENCE, SOLUBILITY, &C.

THE properties of ſimple and neutral ſalts, which we have conſidered in each ſingly, require to be again attended to, in a comparative view, in order to deduce ſeveral uſeful general reſults; with this intention, we ſhall proceed to treat of their cryſtallization, fuſibility, effloreſcence, deliqueſcence, and ſolubility in water.

Cryſtallization, conſidered in general in all the bodies which poſſeſs that property, conſiſts in a tendency to aſſume a regular form under certain circumſtances. Moſt minerals poſſeſs it; but it is more eminent in ſaline ſubſtances than in any others. The circumſtances which favour its exiſtence (and without which it cannot take place), are reducible to the two following, as far as relates to ſalts: 1. The particles muſt be divided, and ſeparated from each other, ſo that they may afterwards tend to unite, by the application of ſuch ſides or faces as have the ſtrongeſt affinity with each other. 2. It is neceſſary that this approach of the parts take place gradually, by the gradual ſubtraction of the fluid. Hence it is eaſily conceived, that cryſtallization is effected by virtue of an attraction between the particles, or the affinity of aggregation, which tends to bring them together. Theſe conſiderations afford reaſon to think, that the integrant parts of a ſalt have a peculiar form, and that the different form affected by each ſaline ſubſtance in its cryſtallization, is a conſequence of this figure. And we are equally led to conclude, that the ſmall polyhedral figures of the particles of ſalt, having ſome faces more extended than others, may have a tendency to approach and unite by ſuch faces as are the largeſt. This being ſuppoſed, it will eaſily be conceived, that when the fluid which kept them aſunder, is ſubtracted, they will unite by ſuch faces as are the beſt adapted, or have the ſtrongeſt affinity to each other; and that if the fluid be withdrawn gradually, ſo as to afford time for the ſaline particles to arrange themſelves in the beſt manner, the cryſtallization will be regular: but on the contrary, that a too ſpeedy privation of the fluid will cauſe them to approach ſuddenly, and to unite by the faces which firſt preſent themſelves; in which caſe the cryſtallization will be irregular, and the form not eaſily determined: or if the evaporation be ſtill more ſudden, the ſalt will take the form of a concrete maſs, of an appearance ſcarcely, if at all, cryſtalline.

The art of cryſtallizing ſaline matters is founded on theſe fundamental truths. All ſalts are cryſtallizable, though with different degrees of facility; ſome cryſtallize ſo readily, that we conſtantly ſucceed in procuring them in their regular form; others require more care and precaution; others again are ſo difficultly obtained in this ſtate, that it has not yet been accompliſhed. To ſucceed in attempts of this nature, it is neceſſary to pay great attention to the particular properties of each ſalt. The firſt ſtep is to diſſolve the ſaline ſubſtance in water: but there are ſome diſſolved with ſo much difficulty, by the means we poſſeſs, that it is almoſt impoſſible to obtain the regular approach of the particles; ſuch are calcareous ſulphat, calcareous carbonat, calcareous fluat, and barytic ſulphat. Nature continually preſents theſe neutral terreſtrial ſalts, in very regular cryſtals, not imitable by art, but after long time: and many eminent philoſophers ſtill doubt the poſſibility of this proceſs, which we give on the authority of Mr. Achard; it conſiſts in paſſing water, which has ſtood a long time on ſalts of difficult ſolubility, through a very narrow aperture, and procuring a very ſlow evaporation. On the contrary, other ſaline matters are ſo ſoluble, and unite ſo ſtrongly with water, that they are not ſeparated but with great difficulty, and are ſcarcely to be obtained in a regular form: this is the caſe with all deliqueſcent ſalts, ſuch as the calcareous and magneſian nitrats and muriats.

It cannot be doubted, but that each ſalt has its peculiar mode of cryſtallization; or, which is the ſame thing, that its integrant parts have a determinate form, differing from that of every other ſalt; ſuch is doubtleſs the cauſe of the remarkable varieties among cryſtals. Simple ſalts, from the ſalino-terreſtrial ſubſtances to the moſt powerful acids, have not in general any diſtinguiſhing form; there are but few circumſtances which, without entirely deſtroying their peculiar ſaline properties, cauſe them to aſſume a cryſtalline form, as is the caſe with the oxygenated muriatic acid, and concrete ſulphuric acid. Bertholet, however, affirms, that cauſtic alkalis cryſtallize in ſcales; and that the acid of borax univerſally exhibits that form. Notwithſtanding this apparent conformity among ſimple ſalts, few of them do take a regular form in our laboratories; whether it be that they are not really ſuſceptible of it, or whether our methods be inſufficient for the purpoſe. But the neutral or middle ſalts all affect a regular form, which may be produced or deſtroyed in moſt of them at pleaſure. When we reflect on this property, ſo different from that of ſimple ſalts, it becomes an object of inquiry, whether it depends on the acids, or on the baſes by which thoſe acids are neutralized. It does not ſeem excluſively to depend either on the one or the other, ſince the ſame acids form ſalts very differently figured, with various baſes; and the ſame baſe, combined with different acids, preſents a like diſſimilarity in its cryſtals. The diverſity of forms in compounds, muſt therefore be attributed to the total change of properties which ariſes from combination.

There are three methods generally uſed in cryſtallizing ſalts in chemical laboratories: 1. Evaporation, which conſiſts in heating a ſaline ſolution, ſo as to diſſipate the water which kept the particles aſunder. The ſlower this evaporation is, the more regular will be the cryſtals obtained. Sulphat of potaſh, the muriats of potaſh and ſoda, calcareous ſulphat, and magneſian carbonat, are cryſtallized in this way. Their form is irregular, if the evaporation be performed too quickly, as for example, by a boiling heat; but by a ſand heat, of about 150 degrees, theſe ſaline ſolutions afford very regular and beautiful cryſtals. There is ſcarcely any ſalt which may not be had in a very diſtinct form by this proceſs, if ſkilfully conducted.

2. Cooling is ſucceſsfully employed with ſuch ſalts as are more ſoluble in hot than in cold water. It is eaſy to conclude that a ſalt of this kind muſt cryſtallize, becauſe it is leſs ſoluble in

water, whoſe temperature is diminiſhed. The portion which remained in ſolution, in conſequence of the heat, will be ſeparated in proportion as the fluid becomes cool; and when it is entirely cold, no more of the ſalt will remain diſſolved than the portion which cold water is capable of ſuſtaining. In this proceſs, as in the former, the more ſlowly the water cools, the more accurately will the ſaline particles approach each other, and in the moſt natural poſitions. For this reaſon, all ſuch ſaline ſolutions muſt be kept for ſome time at a certain degree of heat, which muſt be afterwards gradually diminiſhed to the freezing point, if neceſſary. It muſt be obſerved, in fact, that all ſalts, which may be cryſtallized by this proceſs, are in general much more ſoluble than thoſe which are cryſtallized by the former proceſs; that a ſudden refrigeration cauſes the exceſs of ſalt to be depoſited in an irregular maſs; and that regular cryſtals can only be obtained by gradual cooling. In this method, beautiful cryſtals of ſulphat of ſoda, nitre, carbonat of ſoda and potaſh, muriat of ammoniac, &c. may be obtained.

3. The third method of cryſtallizing ſalts, is by ſpontaneous evaporation. With this intention, a pure ſaline ſolution is expoſed to the temperature of the air, in capſules of glaſs, or earthen ware, covered with gauze, to prevent duſt from falling into it, without impeding the evaporation of the water: a ſeparate chamber, or loft, uſed for no other purpoſe, is beſt adapted to this operation. The ſolution is to be left till cryſtals are perceived, which in ſome ſalts does not happen in four or five months, or longer. This proceſs, in general, ſucceeds better than any other, for obtaining very regular cryſtals of conſiderable magnitude; and ought to be employed with all ſalts, if time permit, as it is a method of obtaining them perfectly pure. Nitrat and muriat of ſoda, borax, the ſulphats of alumine, magneſia, and ammoniac, and ammoniacal nitrat, &c. may be treated in this manner. In ſome circumſtances, more than one of theſe proceſſes are advantageouſly uſed at the ſame time; more eſpecially when the very deliqueſcent ſalts, ſuch as calcareous nitrat and muriat, magneſian nitrat and muriat, &c. are to be cryſtallized. Theſe ſolutions are ſtrongly evaporated, and immediately expoſed to an intenſe cold; this method, however, affords only irregular cryſtals, and ſometimes con-

crete maſſes, of an intermediate figure. The want of ſucceſs, in cryſtallizing a conſiderable number of neutral ſalts, ariſes from its not being preciſely determined to what ſtate of concentration each ſolution ought to be brought, in order to afford cryſtals. The work, which is eaſy, and only requires time and patience, has not been completely followed by chemiſts. This uſeful piece of knowledge conſiſts in the ſpecific gravities of the ſaline ſolutions: its advantages have already been perceived in ſeveral manufactories where ſaline matters are treated in the large way; an areometer or hydrometer being uſed to determine the requiſite degree of denſity or concentration of the ſaline ſolutions.

Beſides theſe different methods of cryſtallizing ſalts, there are ſeveral circumſtances which aſſiſt their operation, whoſe influence it is neceſſary to bring into the account. A ſlight motion is ſometimes uſeful in producing cryſtallization: thus we find, that by carrying from place to place the cups containing ſaline ſolutions, the cryſtallization is completed a few inſtants after the ſlighteſt agitation. I have already obſerved, that this phenomenon takes place more eſpecially in calcareous nitrat and muriat. The contact of air is likewiſe indiſpenſably neceſſary for the formation of cryſtals. It frequently happens, that a ſolution, evaporated to the requiſite degree for affording cryſtals, remains fluid throughout, in a well cloſed bottle; though the ſame ſolution cryſtallizes readily, if expoſed to the air in a cup: this obſervation was very accurately made by Rouelle the elder. The form of the veſſels, and the immerſion of foreign bodies in ſaline ſolutions, greatly influence their cryſtallization. The firſt modifies the figure of the cryſtals, and produces a very great variety: for this reaſon it is, that threads, or ſmall ſticks, are placed with great advantage in the cups containing the ſaline ſolution. For the cryſtals which adhere to the threads, having baſes of inconſiderable magnitude, are commonly of the moſt regular form; while ſuch as fix themſelves to the oblique, irregular, and unequal ſides of the veſſels commonly employed for this uſe, are more or leſs truncated and irregular. Foreign bodies, plunged in ſaline ſolutions, have likewiſe another advantage; they promote the formation of cryſtals, which would otherwiſe have been much more ſlowly effected. Thus it is, that a piece of wood, or a ſtone, thrown into a ſalt ſpring, becomes a baſe, on which the water depoſits cryſtals of muriat of ſoda. From the obſervation of this phenomenon, ſome chemiſts have propoſed to add a ſaline cryſtal to the ſolution of a ſalt which does not readily cryſtallize; and many have affirmed, that the cryſtallization of ſalts, which it is very difficult to obtain in a regular form, is greatly favoured by this means. Such are the principal cauſes which influence the cryſtallization of ſalts: there are doubtleſs many others, which the future obſervation and inquiries of chemiſts will make known.

The ſeparation of any ſalt from water, which holds it in ſolution, cannot be effected in a regular form, unleſs the ſalt retains a portion of the fluid. This may be ſhown, in a convincing manner, by diſſolving in water a ſalt reduced to powder by heat, ſuch as calcined ſulphat of alumine, or borat of ſoda, or ſulphat of ſoda, fallen into efflorefcence, which will be found ſometimes increaſed to double in their cryſtallization; that is to ſay, an ounce of the ſalt treated in this manner, will afford two ounces of cryſtals. Whence it is concluded by chemiſts, that a well cryſtallized ſalt contains more water than the ſame ſalt deprived of the cryſtalline form by the action of fire or air. They have called this water by the name of *water of cryſtallization*, becauſe it is in fact one of the elements of ſaline cryſtals, which loſe their tranſparency and regular form when deprived of it. Various ſalts contain very different quantities of the water of cryſtallization. Some contain the half of their weight, as the ſulphat and carbonat of ſoda, and ſulphat of alumine; others retain only a ſmall quantity, as nitre, muriat of ſoda, &c. The relative quantity of water of cryſtallization in all cryſtallizable ſalts, has not been well determined. It may be abſtracted from ſalts without their eſſential properties being in any reſpect altered, and is itſelf perfectly pure and ſimilar to diſtilled water.

As we have ſeen that various ſaline ſubſtances do not cryſtallize by the ſame proceſſes, or in circumſtances preciſely ſimilar, it is clear that this property may be advantageouſly uſed as the means of ſeparating them from each other. In this manner a ſalt cryſtallizable by cooling, may be obtained ſeparate from another ſalt, which is cryſtallizable only by continuing the evaporation; as is obſerved in the ſalt ſprings of Lorraine, which contain muriat and ſulphat of ſoda. Notwithſtanding this, it frequently happens, that two ſalts diſſolved in the ſame water, however different their manner of cryſtallization may be, do neverthleſs vitiate each other's cryſtals, and cannot be obtained ſeparate, but by repeated ſolutions and cryſtallizations. This obſervation applies ſtill more ſtrongly to ſuch ſalts as cryſtallize nearly at the ſame time, which are more difficult to ſeparate from each other, eſpecially if they be numerous. For example, if the ſame water contain four ſalts alike cryſtallizable by evaporation, or cooling, it will be impoſſible to ſeparate them by one or two ſucceſſive cryſtallizations; and theſe operations muſt be multiplied a conſiderable number of times, that the ſlight differences between their manner of cryſtalization may produce the deſired effect: for it muſt be remarked, that no two ſalts are preciſely alike as to their manner of cryſtallization by cooling or evaporating. If ſuch exiſted they would always cryſtallize together, and could never be obtained ſeparate by this method; a circumſtance which in fact happens with ſuch ſalts as greatly reſemble each other in this property. There are other ſalts which are not ſeparable by cryſtallization, becauſe they adhere or combine together; ſuch in general are the neutral ſalts formed by the ſame acid, and cryſtallizable by the ſame proceſs, as the ſulphats of magneſia and ammoniac. But theſe ſingular adheſions of neutral ſalts have not yet been ſufficiently examined, though the ſubject well deſerves the attention of chemiſts.

Laſtly, To conclude this ſhort hiſtory of the cryſtallization of ſalts, we muſt add, that there is another method of obtaining them, which conſiſts in precipitating them from their ſolutions by the addition of a ſubſtance which has a ſtronger affinity for water. Thus, for example, ſpirit of wine poured into a ſaline ſolution, produces this effect on moſt neutral ſalts; thoſe only excepted which are ſoluble in that menſtruum. The ſame phenomenon of the precipitation of ſaline cryſtals takes place in the mixture of ſome ſalts, whoſe ſolubility is very different, and even ſometimes by the mixture of ſeveral ſaline ſolutions with each other. Thus we find that ſulphat of magneſia diſſolved in water appears to precipitate a ſolution of ſulphat of ammoniac in the form of cryſtals; but the other facts, which accompany theſe ſingular admixtures, have not been ſufficiently aſcertained to juſtify any attempt towards forming a theory.

The fuſibility of ſalts by heat having been treated of under each particular article, we ſhall here take a comparative view of this property. Two kinds of fuſibility are diſtinguiſhable in ſalts; the one produced by the water they contain, and called the *aqueous fuſion;* the other, properly belonging to the ſaline matter, and termed the *igneous fuſion.* The aqueous fuſion depends entirely on the water of cryſtallization being in ſufficient quantity to diſſolve the ſalt at a certain temperature. The cryſtalline form then diſappears, and the ſalt is really diſſolved; a fact which is ſufficiently proved by continuing the application of heat for a ſufficient time to a ſalt of this nature, ſuch as ſulphat of ſoda, borat of ſoda, ſulphat of alumine, &c. which become dry, and no longer appear melted after the water of ſolution is diſſipated. The apparent or aqueous fuſion likewiſe appears to be independent of the true igneous fuſion, from the circumſtance of this laſt appearing in all thoſe ſalts which are ſuſceptible of the other. When muriat or borat of ſoda, for inſtance, have paſſed the aqueous fuſion, and become dry, they may be again melted by a ſtrong heat. The true igneous fuſion is not produced in all ſalts by the ſame degree of heat; there are ſome that melt as ſoon as they become red, as nitrat and muriat of ſoda; others require a moſt violent degree of heat to fuſe them, as the ſulphats of potaſh and ſoda. Laſtly, There are others whoſe fuſibility is ſuch, that they communicate the ſame property to the moſt refractory bodies; in this manner it is that fixed alkalis combine with and melt quartz, ſand, and all other ſilicious earths which are not fuſible alone. Theſe ſalts are called *fluxes* from this property, and becauſe they are uſed to facilitate the fuſion of earthy and metallic ſubſtances. We have elſewhere remarked, that volatility is the extreme of fuſibility; and we may here add, that all ſaline matters are more or leſs volatile, no ſalt being ſufficiently fixed to withſtand the action of a violent heat. Thus, ſulphat of potaſh and muriat of ſoda are ſublimated into vapour when expoſed to a very high temperature.

The alterations to which cryſtallized ſalts are ſubject by expoſure to air, are not all alike. Some experience no ſenſible change; others loſe their tranſparent form, either gradually becoming fluid with an increaſe of weight, or becoming pulverulent by the loſs of a part of their maſs. The firſt of theſe changes is called deliqueſcence, and the latter effloreſcence.

The phenomenon termed deliqueſcence, takes its name from the ſaline matter becoming liquid: it is likewiſe ſaid that a ſalt falls into *deliquium*, when it melts in this manner by the contact of air. It appears to be the conſequence of a true elective attraction, which is ſtronger between the ſalt and the water, than between the latter and the air of the atmoſphere. All ſalts do not deliqueſce with equal rapidity, nor attract equal quantities of water from the atmoſphere. Fixed alkalis, ammoniacal gas, muriatic acid gas, and concentrated ſulphuric acid, ſeize the water of the atmoſphere, and render it very dry, by abſorbing more than their own weight of that fluid. The appearance is more eſpecially remarkable in ſulphuric acid congealed by cold, and dry potaſh. Theſe two ſalts firſt become ſoft, and ſoon acquire a denſe fluidity ſimilar to that of certain oils, which has occaſioned the firſt to be called *oil of vitriol*, and the ſecond *oil of tartar;* though theſe names are far from being ſignificant, and may lead beginners into miſtakes Others, though not ſo greedy of moiſture, nevertheleſs attract it very ſtrongly; as for example, calcareous nitrat and muriat, nitrat, and muriat of magneſia. Laſtly, There are ſome which become ſlightly moiſt, and do not completely deliqueſce; ſuch as nitrat of ſoda, muriat of potaſh, ſulphat of ammoniac, &c.

Effloreſcence was ſo denominated from the ſalts, which are ſuſceptible of it, becoming covered with a white ſubſtance ſimilar to that which is known in chemiſtry by the name of *flowers*. This property is the reverſe of deliqueſcence; for as that happens by the decompoſition of the humid atmoſphere, by the ſtronger elective attraction of ſaline cryſtals for moiſture; ſo on the other hand, in effloreſcence the ſaline cryſtals are decompoſed, becauſe the air has a ſtronger affinity with water than thoſe cryſtals have. Efflorеſcence is, therefore, a loſs of the water of cryſtallization, in conſequence of which the ſalts loſe their tranſparency and conſiſtence, and become lighter. It is of importance to be obſerved, that ſaline cryſtals which effloreſce, are ſubjected to the ſame alteration as would be produced by fire in a much ſhorter time; that is to ſay, they are ſlowly calcined, and loſe exactly the ſame weight as drying by heat would deprive them of: to this we muſt likewiſe add, that effloreſcent ſalts are of the moſt ſoluble claſs which cryſtallize by cooling their ſolutions.

Effloreſcence, like deliqueſcence, is a property which greatly varies in the ſeveral neutral ſalts. Some ſalts, ſuch as ſulphat of carbonat and ſoda, readily effloreſce, and continue to fall in pieces, till the whole becomes a fine white powder; and as they loſe by this means half their weight, it may be concluded, that their property of effloreſcing ſo completely, is a conſequence of a large quantity of water which enters into their cryſtals: and in fact, we find that ſalts which effloreſce very little, ſuch as borax, ſulphat of alumine and magneſia, do not contain ſo large a quantity of that fluid in their cryſtals. If effloreſcence depend on a ſtronger elective attraction, between air and water, than between water and the ſalt, the phenomenon will take place more readily and effectually when the atmoſphere is very dry, while air loaded with moiſture will not have the ſame action on them. This aſſertion may be confirmed, by ſprinkling a ſmall quantity of water on cryſtals capable of effloreſcence; for the atmoſphere ſeizing this water, and becoming ſaturated, does not act on, or alter the cryſtals; but if this operation be not repeated from time to time, the air combines with the water of cryſtallization, and the effloreſcence takes place. This is daily obſerved by druggiſts, who find it neceſſary to moiſten ſulphat of ſoda or *Glauber's ſalt* with a ſmall quantity of water, that the form of the cryſtals may be well preſerved.

The diſſolution of ſalts in water, is a phenomenon which highly deſerves the attention of chemiſts. Some perſons having obſerved that this is effected without any ſenſible motion or effervеſcence, ſuch as accompanies the ſolution of metals in acids, have propoſed to diſtinguiſh the latter by the word *ſolu-*

tion, and the former by that of *diſſolution.* But there is no difference in the ſenſe of either of theſe terms; and the mutual action of acids and metals being entirely different from the ſolution of ſalts in water, and depending on peculiar cauſes, hereafter to be explained, no advantage would be derived from this diſtinction. The ſolution of ſalts in water has been conſidered by ſome philoſophical chemiſts as a ſimple mechanical diviſion of the ſaline particles; but there is an intimate penetration, which takes place between theſe two bodies, attended with a change of temperature; and it ſeems that a true combination takes place between the ſalts and the water, which can by no means be explained, on the ſuppoſition of the ſaline particles being ſimply divided. This is proved, not only by the change of temperature, but likewiſe by the practicability of ſeparating any ſalt from its ſolution, by the addition of another; as potaſh precipitates ſulphat of potaſh, and carbonat of lime, from waters which hold them in ſolution. The precipitations of ſalts by each other are far from being all known; and the ſcience of chemiſtry would derive great advantage from a connected ſeries of experiments on this ſubject. It may be obſerved, in the particular hiſtory of each ſaline ſubſtance, that they all poſſeſs different degrees of ſolubility, from conſtant fluidity, ſuch as exiſts in the ſulphuric and nitric acids, to almoſt perfect infuſibility; as ſulphat of barytes. Many chemiſts have publiſhed tables of the different ſolubility of ſalts; but theſe tables will be inaccurate and imperfect, till experiments have been ſufficiently multiplied to eſtabliſh the exact proportions between the different ſolubilities. We muſt here add, that all ſimple ſalts, whether alkaline or acid, conſtantly produce heat, when diſſolved in water; whereas cold is always produced during the ſolution of neutral ſalts. The meaſure of theſe changes of temperature is not well aſcertained in all kinds of ſalts, but this phenomenon is more attended to at preſent than formerly. It will doubtleſs lead the way to valuable diſcoveries: we already begin to perceive certain truths, whoſe exiſtence was formerly not ſo much as ſuſpected. For example, when we obſerve, that neutral ſalts, which produce the greateſt cold in their ſolution, as ſulphat of ſoda, nitrat, muriat of ammoniac, are much more ſoluble in hot than in cold water, may we not conclude, that this ſolubility depends on the water then poſſeſſing a more conſiderable quantity of heat, which it is neceſſary they ſhould abſorb, to become melted, and take the liquid ſtate? This exceſs of heat, being eaſily carried off by the air and ſurrounding bodies, a part of the ſalt is precipitated in the cryſtalline form during the cooling.

CHAPTER XIII.

CONCERNING THE ELECTIVE ATTRACTIONS WHICH TAKE PLACE BETWEEN THE SEVERAL SALINE SUBSTANCES.

THE diſcoveries made in conſequence of the numerous experiments made by chemiſts, on ſaline matters, ſince the middle of the preſent century, have ſhown, that ſaline ſubſtances have very different degrees of affinity, or elective attraction, among each other. Geoffroy is the firſt who compared them; but later diſcoveries have ſhown, that his table contains many errors. Bergman has corrected them, and has added a much greater number of elective attractions between all the ſalts; however, on conſulting the ſeveral articles of the table of this celebrated Swediſh chemiſt, we find that many of them are not yet eſtabliſhed on a ſufficient number of accurate experiments, and that he himſelf acknowledges their uncertainty. Without extending the theory of elective attractions to ſo large a number of baſes as Bergman has done, we ſhall confine ourſelves to the preſent ſtate of chemiſtry, in our examination of the affinities which are exerted between thoſe ſaline matters, whoſe nature and properties are beſt known.

Among the ſix ſpecies of acids we have examined, the ſulphuric appears to be the ſtrongeſt in its elective attractions; that is to ſay, it deprives other acids of moſt of their alkaline or ſalino-terreſtrial baſes. Thus it decompoſes nitrats, muriats, fluats, borats, and carbonats, by diſengaging their acids.

The nitric acid in general occupies the ſecond rank, yielding the alkaline baſes to the ſulphuric acid, but depriving the four following acids of them.

To ſhow the different affinities which obtain between the mineral acids and the ſaline baſes of the ſame kingdom, to the beſt advantage, we ſhall exhibit them in the order or arrangement of Bergman; by conſidering, 1ſt, Each acid, with reſpect to the different baſes it can unite with; 2d, Each alkaline matter, with reſpect to the acids which ſaturated it, and the degree of adheſion with which it unites to thoſe ſalts.

I. The elective attractions of the ſulphuric acid, for the different baſes, are diſpoſed, by Bergman, in the following order, beginning with that to which it moſt ſtrongly adheres.

SULPHURIC ACID *.

Barytes.
Potaſh.
Soda.
Quick-lime.
Ammoniac.
Magneſia.
Alumine.

Though the nitric and muriatic acids have the ſame order of elective attractions for alkaline baſes, we ſhall nevertheleſs exhibit them at length.

NITRIC ACID.

Barytes.
Potaſh.
Soda.
Quick-lime.
Ammoniac.
Magneſia.
Alumine.

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* We have already exhibited the order of the affinities of acids, with the baſes, in the hiſtory of each; but we think proper to repreſent them here in columns, as is uſually done in tables of affinities, that they may be ſeen and compared on inſpection. F.

Muriatic Acid.

Barytes.
Potaſh.
Soda.
Quick-lime.
Ammoniac.
Magneſia.
Alumine.

Barytes has therefore a ſtronger affinity with the ſulphuric, nitric, and muriatic acids, than every other baſe, and decompoſes all the neutral ſalts formed by theſe acids, and other alkaline matters. Bergman places magneſia before ammoniac, becauſe, he affirms, that this ſalino-terreſtrial ſubſtance decompoſes ammoniacal ſalts. We muſt obſerve, that ammoniac decompoſes magneſian ſalts more completely; in fact, all the magneſian is not precipitated by this alkali, the fluid retaining in ſolution mixed or triple ſalts, formed by the union of the magneſian with the ammoniacal ſalts. We apprehend, notwithſtanding our reſpect for the authority of Bergman, that there is a ſtronger elective attraction between the acids and ammoniac, than between the ſame ſalts and magneſia, becauſe the latter, though it diſengages a ſmall quantity of ammoniac from ammoniacal ſalts in the humid way, does not decompoſe them by diſtillation; and for that reaſon we have placed ammoniac before magneſia, and think the correction is neceſſary to be made in Bergman's table.

II. The elective attractions of the fluoric acid for alkaline baſes, are very different from thoſe of the three foregoing. Alkalis yield this acid to lime, and two other ſalino-terreſtrial ſubſtances. A ſolution of barytic fluat in hot water is precipitated by lime-water, which immediately forms calcareous fluat. The ſame thing happens with other fluoric neutral ſalts; lime ſeizing the acid as the eighth column of Bergman's table, arranged hereunder denotes.

Fluoric Acid.

Quick-lime.
Barytes.
Magneſia.
Potaſh.
Soda.
Ammoniac.
Alumine.

The ſame phenomena take place by the dry way; for calcareous fluat is not decompoſed by pure and cauſtic fixed alkalis, though it is by the carbonats of potaſh and ſoda.

III. Bergman, in his tenth column, exhibits the affinities of the boracic acid, in the ſame order as thoſe of the fluoric acid; becauſe, when borax is heated in water with quick-lime, the latter ſeizes its acid, forming the ſcarcely ſoluble calcareous borat, and leaves the ſoda in a ſtate of purity. As to the other baſes, he has diſpoſed them by analogy, and conſiders the diſpoſition as nothing more than a probable conjecture *.

Boracic Acid.

Quick-lime.
Barytes.
Magneſia.
Potaſh.
Soda.
Ammoniac.
Alumine.

IV. The elective attractions of the carbonic acid are ſomewhat different from theſe. It adheres more ſtrongly to barytes, and after that to lime, than to any other ſubſtance. Its combination with magneſia is likewiſe deſtroyed by ammoniac, as Bergman has proved by accurate experiments. The following

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* Quod idem accidat cum alkali vegetabili, acido boracis ſaturato, hactenus tantum probabilis eſt conjectura, æque ac terræ ponderoſæ, et magneſiæ poſitura.

extract of the twenty-fifth column of the table of this celebrated chemiſt, expreſſes the order of the attractions of the carbonic acid for the ſeveral ſaline baſes.

CARBONIC ACID.

Barytes.
Quick-lime.
Potaſh.
Soda.
Magneſia.
Ammoniac.
Alumine.

V. The ſeven earthy, or alkaline baſes, whoſe combinations with the mineral acids we have examined, have different elective attractions for thoſe acids, when compared together; five of them, namely, the two fixed alkalis, ammoniac, lime, and alumine reſemble each other in the order of their affinities. All the five adhere to acids in the following order; the ſulphuric, nitric, muriatic, fluoric, boracic, and carbonic acids; but barytes and magneſia have different affinities from the foregoing, though they agree with each other.

Bergman diſpoſes the elective attractions of barytes and magneſia, with reſpect to the mineral acids, in the following manner.

BARYTES AND MAGNESIA.

Sulphuric acid.
Fluoric acid.
Nitric acid.
Muriatic acid.
Boracic acid.
Carbonic acid.

There is no difference between this order of affinities, and that of the other five baſes, except that the fluoric acid is before the nitric and muriatic acids, which ſhows, that the barytic and magneſian nitrats and muriats, are decompoſed by the fluoric acid; while the barytic and magneſian fluats do not yield their baſes to the nitric and muriatic acids.

VI. The elective attractions we have exhibited, ſhow the order of ſimple decompoſitions, which take place on the mixture of three ſaline bodies; but it is equally neceſſary that the chemiſt ſhould attend to the double affinities, or decompoſitions which take place when four ſubſtances are mixed together.

It muſt be recollected, that by double affinity is underſtood a combined force, by virtue of which, a compound of two bodies, which cannot be ſeparated neither by a third nor a fourth body, preſented ſeparately, is nevertheleſs decompoſed with the greateſt facility, when the two laſt are combined together. This double elective attraction is very often exerted between neutral ſalts. In this manner it is, that the ſulphat, nitrat, and muriat of lime, are not decompoſed by ammoniac, or by the carbonic acid alone; becauſe the firſt of theſe bodies has a leſs affinity than lime with the ſulphuric, nitric, or muriatic acids, while the ſecond has a leſs affinity than lime with the ſame acids: but when a compound of ammoniac and carbonic acid is preſented to theſe calcareous ſalts, the adheſion of their principles will be deſtroyed. I have ſhown, in the firſt volume of this work, where affinities are generally treated of, that the cauſe of this phenomenon might be explained, by aſſuming numbers to expreſs the different degrees of elective attraction. I have attempted to apply this idea to ſaline ſubſtances; but as the nature and combinations of the fluoric and boracic acids are not yet well known, I have conſidered only the ſulphuric, nitric, muriatic, and carbonic acids, with reſpect to the ſaline mineral baſes. The numbers I have aſſumed to expreſs the different degrees of adheſion to thoſe baſes, are founded on the reſult of ſimple decompoſitions. It muſt be noted, that they are not perhaps accurately proportioned to the forces of affinity, but are chiefly deſigned to explain the cauſe of double elective attractions.

I ſhall, in this place, firſt give a table of numbers, expreſſing the affinities of the four acids above enumerated, with fix baſes: I do not comprehend barytes, becauſe its ſeveral ſaline combinations are not yet ſufficiently known. After which, I proceed to exhibit the known effects of double affinity among neutral ſalts, according to the method of diſpoſition invented by Bergman, which I have already deſcribed in the general chapter on Affinities. I muſt here repeat, that in this ingenious diſpoſition, to which I have only added the numerical expreſſion, the ſum of the two vertical numbers, which denote the divellent attractions, muſt exceed that of the horizontal numbers, which indicate the quieſcent attractions, in order that a double decompoſition may follow.

TABLE of the Degrees of Attraction between Four Acids and Six Baſes, expreſſed in Numbers.

FIRST COLUMN.

The ſulphuric acid has an affinity of combination with	Potaſh equal to	8
	Soda	7
	Quick-lime	6
	Ammoniac	4
	Magneſia	3½
	Alumine	2

SECOND COLUMN.

The nitric acid has an affinity of combination with	Potaſh equal to	7
	Soda	6
	Quick-lime	4
	Ammoniac	3
	Magneſia	2
	Alumine	1

THIRD COLUMN.

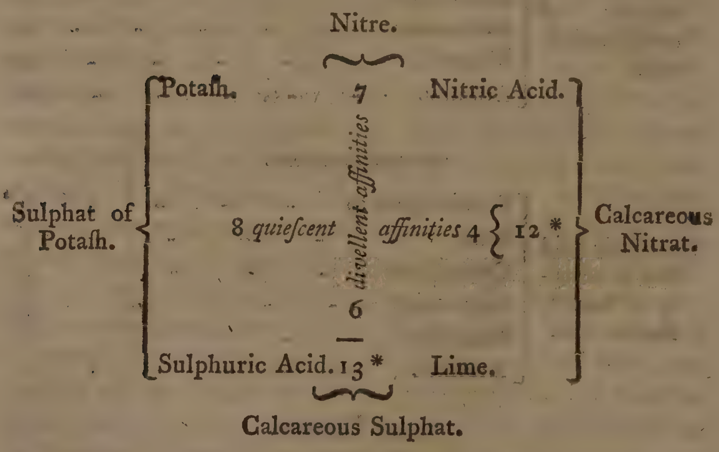
The muriatic acid has an affinity of combination with	Potaſh equal to	6
	Soda	5
	Quick-lime	3
	Ammoniac	2
	Magneſia	1
	Alumine	½

FOURTH COLUMN.

The carbonic acid has an affinity of combination with	Quick-lime equal to	3
	Potaſh	2
	Soda	1
	Ammoniac	$\frac{3}{4}$
	Magneſia	$\frac{1}{3}$
	Alumine	$\frac{1}{4}$

TABLE of Ten Decompoſitions by Double Affinity, which take place between ſeveral Neutral Salts, and are expreſſed by Numbers, taken from the foregoing Table.

EXAMPLE I.



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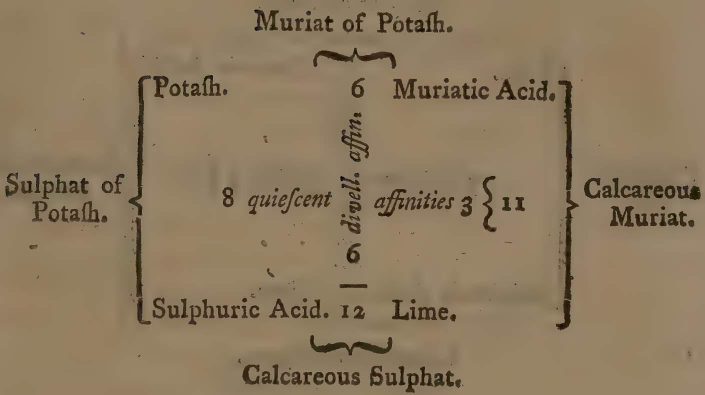
* Theſe numbers denote the ſums of the quieſcent and divellent affinities.

EXAMPLE II.



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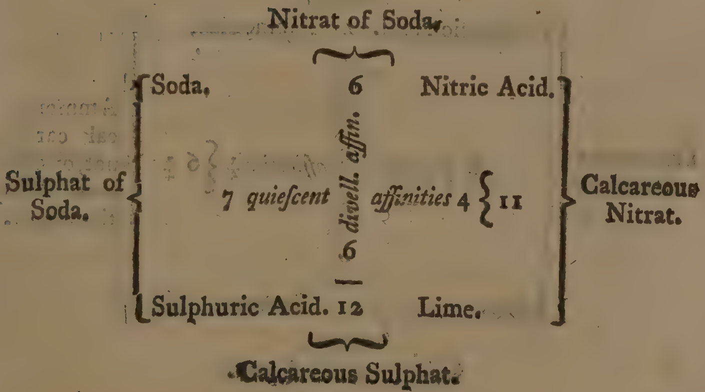

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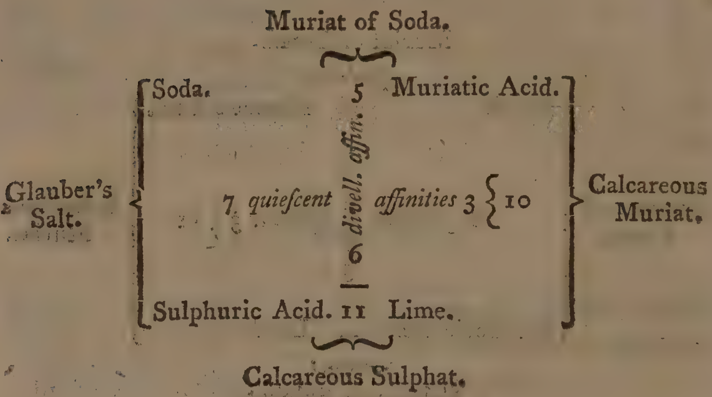

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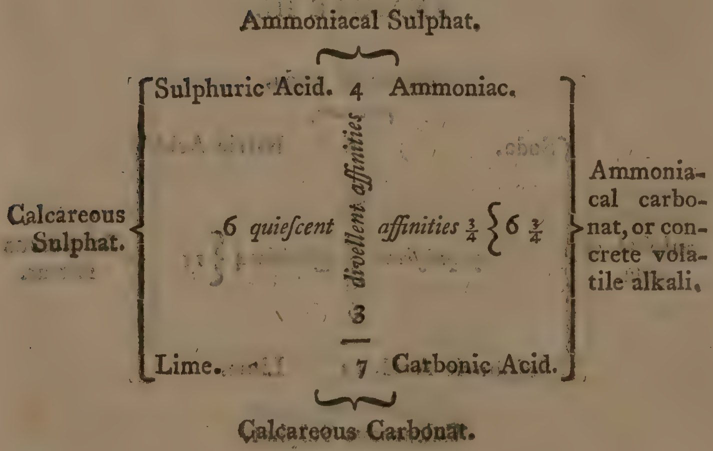

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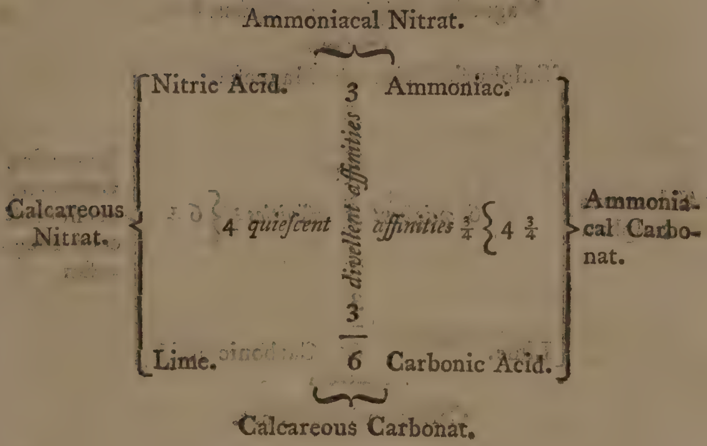

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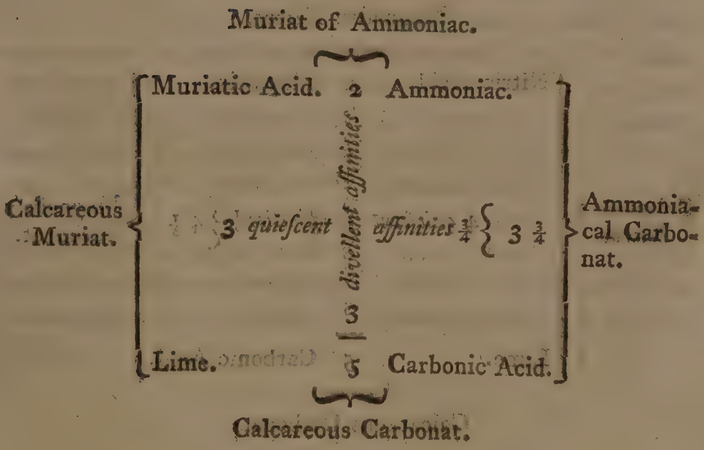
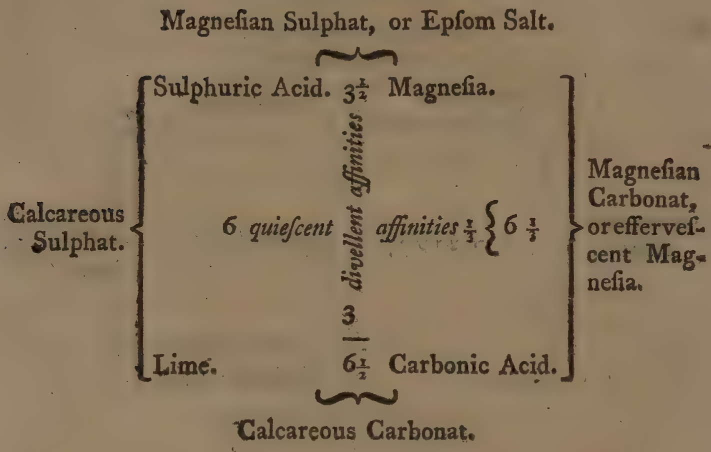
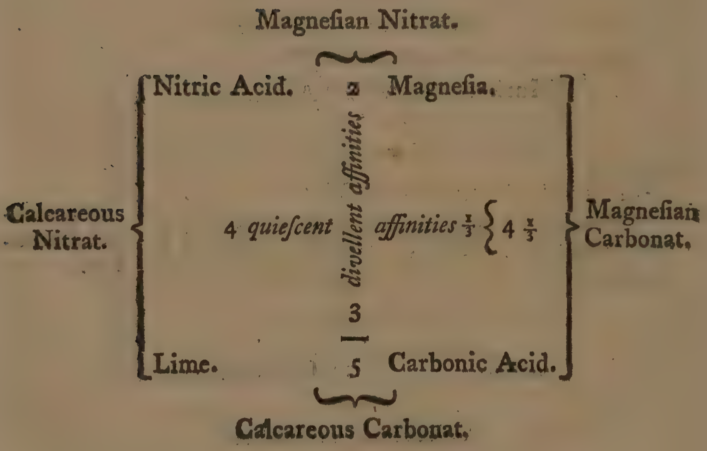


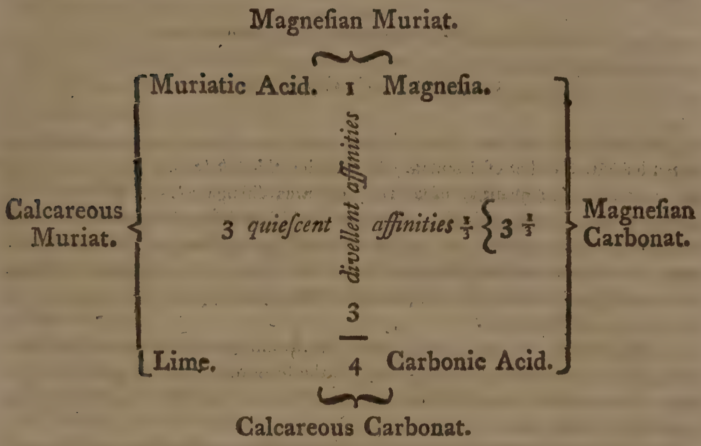
EXAMPLE VIII.



EXAMPLE IX.



EXAMPLE X. AND LAST.



Theſe ten examples of double affinity are not the only inſtances of this kind of decompoſition which takes place among the neutral ſalts we have examined. We have ſeen, for inſtance, that barytic ſalts are not decompoſed by potaſh, while the carbonats of potaſh and ſoda decompoſe them; that calcareous fluat preſents the ſame phenomenon. Theſe two kinds of double affinity, and perhaps others which are not yet known, among ſalts, are not repreſented in the foregoing table, becauſe the elective attractions of barytes and fluoric acid are not yet ſufficiently aſcertained to be expreſſed by numbers. When the neceſſary inquiries have been made, theſe numbers will doubtleſs require to be changed, but the method will remain unchanged, and is capable of improvement only in point of accuracy.

NOTES ON CHAPTER VI.

SULPHAT OF AMMONIAC.

a The effects of heat on ſulphat of ammoniac have been more accurately obſerved by Mr. Hatchet of London. In diſtilling this ſalt by itſelf, he remarked, that a conſiderable quantity of alkaline gas was diſengaged. A white cloud of very minute gliſtering cryſtals was formed, which quickly diſappeared, and was followed by a great quantity of ſulphureous acid gas and water. In this experiment, the ſalt was not only decompoſed, but alſo a part of the ammoniac reſolved into its conſtituent principles. A portion of the undecompoſed ſalt was ſublimed into the neck of the retort.

The ſulphureous acid gas, uniting with the alkaline gas in the receiver, formed the ſulphite of ammoniac, which appeared in the form of the minute gliſtering cryſtals. The gas which remained after this combination ſeemed to poſſeſs all the properties of azotic gas.

When ſulphat of ammoniac was diſtilled with yellow oxyd of iron, pure ammoniac came firſt over, and afterwards ſome ſulphureous acid. The iron was converted to the ſtate of a red oxyd, and mixed with ſome ſulphat of iron.

With oxyd of zinc the reſidue was the ſulphat of that metal.

Minium triturated with ſulphat of ammoniac immediately decompoſed it like lime or alkalis, and, when diſtilled together, the retort contained ſulphat of lead.

When native green oxyd of copper was diſtilled with ſulphat of ammoniac, the reſidue conſiſted partly of red oxyd, and ſome ſulphat of the ſame metal. The ammoniac in this experiment came over in a concrete ſtate, by reaſon of the carbonic acid contained in the green copper. *Philoſ. Tranſ. for* 1796. p. 29.

b This ſalt is decompoſed by phoſphat of lime in the following manner: Bones calcined to whiteneſs, pulverized, and well waſhed in acetous acid, to diſſolve the lime, or carbonat of lime, which may exiſt in the bones, are put into a ſolution of ſulphat of ammoniac. After filtering the liquor, the preſence of phoſphoric acid may be ſhown by adding ſome lime-water, which produces a copious precipitate of the phoſphat of lime. It holds alſo a ſmall portion of the ſulphat of lime in ſolution, as may be ſeen, by pouring into it a ſolution of oxalat of potaſh. But the greater part of the ſulphat of lime remains on the filter with the undecompoſed bone. This reſidue, when dried, is found to weigh 0, 52 parts more than the phoſphat of lime originally employed. See *Journ. Polytechnique*, p. 434.; *Ann. de Chem.* Tom. VI. p. 37. Tom. XII. p. 26.

SULPHITE OF AMMONIAC.

c This ſalt is formed by paſſing ſulphureous acid gas into concentrated liquid ammoniac. During this combination, a conſiderable quantity of caloric is evolved.

On cooling, regular and tranſparent cryſtals are depoſited, but a portion of the ſulphite of ammoniac ſtill remains diſſolved in the water. In order to procure this portion, the liquor is to be expoſed to a gentle heat. If the heat be raiſed too high, the ſalt will be evaporated; and if the evaporation be too long continued, it will be converted into ſulphat of ammoniac.

The uſual form of this ſalt is that of a ſix-ſided priſm, terminated by a hexahedral pyramid. Its taſte is freſh and poignant, leaving at laſt an impreſſion ſimilar to that of ſulphureous acid. Expoſed to the air, it attracts humidity, but it ſoon cryſtalizes again.

Encloſed in a proper apparatus, with oxygen gas, it abſorbs in a few days that elaſtic fluid, and is converted into ſulphat of ammoniac. This combination takes place ſooner when the ſalt is diſſolved in water than when it is expoſed in its cryſtallized ſtate. To preſerve it, therefore, it becomes neceſſary to ſhut it up in veſſels to which the atmoſpheric air has no acceſs.

Water diſſolves its own weight of this ſalt in the temperature of 10° of Reamur. During the ſolution, if large quantities be uſed, the temperature will ſink to 2° of the ſame ſcale.

It is ſoftened and decrepitates in a briſk fire; but it does not melt in the water of cryſtallization, like ſulphat of ammoniac. Diſtilled in a retort with a mercurial apparatus, it gives out a ſmall quantity of ammoniac and water, and is afterwards wholly ſublimed into the neck of the retort. The ſalt ſublimed reddens the tincture of turnſole, and is capable of ſaturating a freſh quantity of ammoniac. It has paſſed in this operation, therefore, to the ſtate of an *acid ſulphite*, in conſequence of the affinity of ammoniac for caloric, and of the ſulphite of ammoniac for the ſulphureous acid. The ſulphite of ammoniac is ſo volatile, that it is impoſſible to convert ſulphat of ammoniac into the ſulphure of ammoniac with charcoal, as is the caſe with the other ſulphats; for the part of the ſalt which has been deprived of a portion of its oxygen is inſtantly volatilized in the form of a ſulphite.

Barytes decompoſes ſulphite of ammoniac either in the dry or moiſt way. A ſolution of this earth produces a copious precipitate on being added to a ſolution of ſulphite of ammoniac. This precipitate is known to be ſulphite of barytes, from its being ſoluble in muriatic acid, from the efferveſcence which it produces and from the odour of ſulphureous acid which it exhales.

Lime produces nearly the ſame effect with barytes, with this difference, however, that the precipitate is leſs ſpeedily formed. When the ſulphat of ammoniac contains an exceſs of acid, the ſulphit of lime is ſometimes obtained in the form of ſmall tranſparent needle-like cryſtals.

Magneſia, in powder, decompoſes ſulphite of ammoniac by heat, and the ammoniac is diſengaged in the elaſtic form. This decompoſition is alſo effected in the moiſt way, though more ſlowly, in a boiling heat. If one ſixth part of magneſia be added to ſulphite of ammoniac, the magneſia will in time diſappear, and a great number of ſmall ſhining cryſtals will be formed on the bottom of the veſſel. Theſe cryſtals, which are almoſt inſipids, are little ſoluble in water, form a triple ſalt, compoſed of magneſia and ammoniac united to ſulphureous acid.

Alumine and ſilex have no action on ſulphite of ammoniac.

All the mineral acids, except the boracic, decompoſe this ſalt. The decompoſition is produced with heat and efferveſcence. The ſulphureous acid gas which is diſengaged does not precipitate barytes from its ſolution in muriatic acid.

The nitric and oxygenated muriatic acids produce more complicated changes. When nitric acid is added to the ſulphite of ammoniac, a mixture of ſulphureous acid gas, and nitrous gas, is diſengaged, The liquor now precipitates barytes from its ſolution in nitric acid, which proves, that while one portion of the nitric acid had united to the ammoniac, another portion of it had been decompoſed by the ſulphureous acid, which is by this converted into the ſulphuric, for the liquor contains ſulphat and nitrat of ammoniac.

Oxygenated muriatic acid produces the ſame effects, but in a different manner. The ſulphureous acid which is diſengaged in this caſe, is ſeparated by the combination of the common muriatic acid and the ſulphuric acid with the ammoniac; for the mixture contains ſulphat and muriat of ammoniac.

The tartarous, oxalic, and citric, are the only vegetable acids which decompoſe ſulphite of ammoniac. This effect is ſlowly produced in the cold, but more quickly in the temperature of boiling water.

All the neutral ſalts with baſe of potaſh, ſoda, or ammoniac, are not changed by this ſalt; but all thoſe with earthy baſes are decompoſed.

Metallic oxyds produce changes in the ſulphite of ammoniac ſimilar to thoſe which they produce in the ſulphites of potaſh and ſoda. The oxyds of zinc, iron, and lead, decompoſe it in part by uniting with its acid while the ammoniac is diſengaged.

Sulphite of ammoniac conſiſts, according to Vauquelin, of

Ammoniac,	29,07
Sulphureous acid,	60,06
Water,	10,87

See *Journ. Polytech.* p. 454.

NITRAT OF AMMONIAC.

[d] Vauquelin remarks that effects ſomewhat different take place when muriatic acid is added to the nitrat of ammoniac. The muriatic acts upon the nitric, takes from it a portion of its oxygen, and converts it into nitrous acid. Oxygenated muriatic acid is formed, and muriat of ammoniac remains diſſolved in the water.

By adding one part of muriatic acid to two parts of nitrat of ammoniac, a liquor may be formed capable of diſſolving gold. In this inſtance, the decompoſition of the nitrat is produced in a ſomewhat different manner. The oxygen of the nitric acid acts immediately upon the gold, and the oxyd is diſſolved, as ſoon as formed, in a portion of the muriatic acid. Nitrous gas is diſengaged, and a muriat, of gold, and a muriat of ammoniac remain in the liquor. By precipitating afterwards this ſolution of gold with a fixed alkali, fulminating gold is formed, or the *orat* of ammoniac; for the alkali not only decompoſes the muriat of gold, but the muriat of ammoniac alſo; ſo that in proportion as the oxyd ſeparates, it unites with the ammoniac, and forms the peculiar fulminating combination. See *Journ. Polytech.* p. 367.

MURIAT OF AMMONIAC.

[e] This ſalt is not formed during the combuſtion of the excrements, but ſeems rather to have pre-exiſted in the dung and urine of theſe animals. It is probable that the muriat of ſoda contained in the plants on which theſe animals are fed is decompoſed during the proceſſes of digeſtion and aſſimilation, and changed into muriat of ammoniac; for Chaptal obſerves, that when animals live on freſh vegetables, their dung affords no muriat of ammoniac; but that in winter, on the contrary, when they are fed on ſalted herbs, it affords a great quantity. The muri-

atic acid probably unites with the ammoniac that is conſtantly formed in the animal economy, and the ſoda remains in combination in the animal humours, which always contain a quantity of it, particularly in combination with phoſphoric acid, which ſeems alſo to be an animal product.

There are ſeveral works for the manufacture of ſal ammoniac, in which this ſalt is formed, by diſtilling all kinds of animal ſubſtances in furnaces which ſerve inſtead of large retorts, and by mixing the aqueous product, impregnated with carbonat of ammoniac, with the mother waters of the ſaline ſprings of La Meurth, Jura, Mont Blanc, &c. which contain the muriats of lime and magneſia. A double decompoſition takes place, in which the muriatic acid unites with the volatile alkali and the carbonic acid to the lime and the magneſia. The two latter combinations being inſoluble in water, are precipitated, while the muriat of ammoniac remains diſſolved. This liquor is evaporated to dryneſs, and the ſalt ſublimed into earthen veſſels, which, by opening into two pieces, facilitate the extraction of this ſalt.

At Franciade they combine the muriatic acid diſengaged from muriat of ſoda by ſulphuric acid with the product of animal matters diſtilled, *dans les tuyaux de fonte*. See *Journ. Polytech.* p. 411.

NOTES ON CHAPTER VII.

SULPHITE OF LIME.

[f] The form of ſulphite of lime is that of a priſm with ſix planes, terminated by a very long pyramid. It has little taſte at firſt, but when kept for ſome time in the mouth, it imparts a manifeſtly ſulphureous taſte to the tongue. This ſalt is very inſoluble in water, but it becomes ſoluble by exceſs of acid. It is obtained in the cryſtallized ſtate, by expoſing its ſolution in ſulphureous acid to the air. The acid is diſſipated, and the ſalt left behind in a ſtate of purity.

Barytes is the only earth which decompoſes it.

Heat converts it into a ſulphat, by depriving it of a portion of its ſulphur.

The mineral acids decompoſe it like the other ſulphites.

Alkalis do not produce any change in it.

Alkaline carbonats, phoſphats, and fluats, are the only ſalts which decompoſe it.

It paſſes very ſlowly to the ſtate of ſulphat, by expoſure to the air.

The greater part of metallic ſolutions decompoſe it.

Sulphite of lime conſiſts of

Lime,	47	
Sulphureous acid,	48	
Water,	5	See *Journ. Polytech.* p. 455.

NITRAT OF LIME.

[g] As the oxalic acid takes the lime from every other acid, and forms with it an inſoluble compound, we uſe it as a teſt of the preſence of lime, either free or in the ſtate of combination.

MURIAT OF LIME.

[h] Carbonat of ammoniac alſo produces a decompoſition of muriat of lime. This ſeems contrary to what has already been ſaid, that the carbonat of lime was decompoſed by the muriat of ammoniac, though in fact there be no contradiction,

for the firſt effect is produced only in the cold, and through the medium of water, the latter decompoſition is produced in the dry way, and in a high temperature. In this laſt caſe the affinities are changed, the caloric tends to unite with the carbonic acid, and to ſeparate it from the lime; the lime, on the other hand, acts ſtrongly on the muriatic acid, and weakens its affinity for the ammoniac, while the carbonic acid attracts the ammoniac, and is volatilized along with it. It is from the union of theſe different forces that the change in the equilibrium of the principles of theſe ſalts, and their reciprocal decompoſition proceeds. In mentioning the degrees of affinity of bodies for each other, it is neceſſary always to attend to the degrees of temperature. See *Journ. Polytech.* p. 414.

NOTES ON CHAPTER VIII.

SULPHITE OF MAGNESIA.

i This ſalt is clear and tranſparent. Its form is that of an elliptical tetrahedral. Its taſte is mild and earthy at firſt, but it afterwards becomes ſulphureous.

It ſoftens by the fire, ſwells and becomes ductile like a gum. It loſes about $\frac{45}{100}$ of its weight by drying. By continuing to heat it after it has loſt the water of cryſtallization, the ſulphureous acid is diſengaged, and magneſia almoſt pure remains in the retort.

Sulphite of magneſia is not very ſoluble in water, but it becomes ſo by exceſs of acid; and this ſolution, expoſed to the air, cryſtallizes very readily, by loſing its exceſs of acid.

It becomes opaque in the air, and is gradually changed into a ſulphat, but this requires a long time.

Fixed alkalis, lime, and barytes, decompoſe it completely. Ammoniac produces only a partial decompoſition, ſo that a triple ſalt is formed.

Alkaline and earthy ſalts, thoſe of alumine excepted, decompoſe it alſo. Mineral acids and metallic ſolutions produce upon it the ſame effects as upon the other ſulphites.

Sulphite of magneſia conſiſts of

Magneſia, -	16	
Sulphureous acid,	39	
Water, -	45	See *Journ. Polytech.*

NITRAT OF MAGNESIA.

k When expoſed to the fire in cloſe veſſels, oxygenous gas is firſt diſengaged, and afterwards vapours of nitrous acid; but undecompoſed, nitric acid ſoon begins to come over, and leaves the magneſia pure in the retort. This decompoſition requires only a very moderate degree of heat, a circumſtance which ſhows that the elements of nitrat of magneſia have only a weak affinity for each other.

Nitrat of magneſia is only in part decompoſed by ammoniac, and a triple ſalt is formed, which Fourcroy firſt obſerved, and which he terms ammoniaco-magneſian nitrat. This ſalt conſiſts, according to Bergman, of 27 magneſia, 43 nitric, and 30 water; but this is not to be depended on; for it is impoſſible to ſeparate the water of cryſtallization, without diſſipating a portion of the nitric acid. See *Journ. Polytech.* p. 381.

NOTES ON CHAPTER IX.

SULPHAT OF ALUMINE.

1 The addition of a certain portion of alkali is now ſhown to be neceſſary to the formation of alum. The neceſſity of this addition had been known for a long time in the manufacturing of this ſubſtance; but it was conceived, that the only uſe of the alkali was to ſaturate the exceſs of acid. Bergman, however, had remarked, that the addition of ſoda or lime did not promote the cryſtalization of alum when uſed as ſubſtitutes for potaſh and ammoniac. He did not, however, ſeem to know that the potaſh entered into the formation of the alum. This curious fact was fully aſcertained by the experiments of Vauquelin. He found, that the addition of the ſulphat of potaſh was equally efficacious in promoting the cyrſtalization of alum with the potaſh itſelf, and that the ſame effect was produced by the ſulphat of ammoniac.

Bergman had alſo obſerved, that not only the common alum, but alſo the Roman, when decompoſed by ammoniac, afforded a ſmall quantity of ſulphat of potaſh. In analyſing the different kinds of alum, Vauquelin found that they all contained ſulphat of potaſh, or of ammoniac, and frequently both of theſe ſubſtances at the ſame time. 100 parts of alum was found to conſiſt of

Sulphat of alumine, - -	49
Sulphat of potaſh, -	7
Water, - -	44
	100

Vauquelin prefers the addition of the ſulphat of potaſh to the pure potaſh, not only becauſe it is cheaper, but alſo becauſe it will not, like the pure potaſh, decompoſe any portion of the ſulphat of alumine. The alum of commerce, therefore, is not to be conſidered as a ſimple binary compound, but rather as a triple, and ſometimes a quadruple ſalt. From this circumſtance Vauquelin diſtinguiſhes ſeven different combinations of ſulphuric acid with alumine. The firſt is the pure *ſulphat of alumine.* This ſalt, which is aſtringent, cryſtallizes in plates, and is ſoluble in water, has not yet been deſcribed.

2. *Acid ſulphat of alumine*, with exceſs of acid. It differs from the former only by giving a red colour to the blue vegetable infuſions. Like the former, this ſalt has not been deſcribed.

3. *Saturated ſulphat of alumine and potaſh.* This is the alum of chemiſts ſaturated with its own earth. It is pulverulent, inſipid, inſoluble in water, incryſtallizable and capable of being converted into true alum, by the addition of ſulphuric acid.

4. *Acid ſulphat of alumine and potaſh.* This ſalt, which is eaſily prepared, has a ſtrong reſemblance to common alum.

5. *Acid ſulphat of alumine and ammoniac.* This ſubſtance, which is eaſily prepared in the laboratory, poſſeſſes all the properties of alum.

6. *Acid ſulphat of alumine, potaſh, and ammoniac.* This is the common alum of the ſhops.

7. *Acidulous ſulphat of alumine and potaſh.* Vauquelin obtained this ſalt by adding a little more potaſh to the alum than is neceſſary for its ordinary cryſtallization. Inſtead of octahedral cryſtals, it afforded a ſalt under the cubic form. See *Ann. de Chem.* Tom. XXII. p. 258, 280; XXIII. p. 222; XXIV. p. 198; XXV. p. 107.

PYROPHORUS.

*[m] It appears from the experiments of Scheele, that alum affords pyrophorus only in proportion to the quantity of fixed alkali which it contains, or in proportion to the quantity of alkali obtained from the combuſtion of the carbonaceous ſubſtance employed. Aluminous earth does not appear to be eſſential to the formation of pyrophorus, for it may be formed by burning a mixture of equal parts of Glauber ſalts and meal, four parts of ſulphat of potaſh with five of meal, equal parts of potaſh and meal with one-fourth of ſulphur; or, according to Bergman, one part of mineral alkali with a fourth of ſulphur, and one-third of charcoal powder; or, according to Scheele, ſulphat of potaſh calcined with three parts of charcoal powder.

Pyrophorus, according to the experiments of Lavoiſier, diminiſhes the volume of atmoſpheric air from 100 to 72½. The diminution of the air by the combuſtion of this ſubſtance, had before this been obſerved by Hales, and confirmed by Prieſtley.

Oxygen gas was reduced to one-ſeventh of its volume by combuſtion with pyrophorus, and when the remainder was waſhed with lime water, and inflamed anew, only a very ſmall portion of the original volume remained undecompoſed.

Prieſtley obſerved that pyrophorus inflames, but more weakly in nitrous gas than in atmoſpherical air. In this experiment the nitrous gas was diminiſhed about one half its volume.

SULPHITE OF ALUMINE

[After " inſoluble in water", p. 66. l. 4. from the bottom.]

[n] Is inſoluble in water, but it becomes abundantly ſo by exceſs of acid. Its ſolution does not cryſtallize by contact of air, but it becomes a ductile and ſoft maſs. Fire diſengages the ſulphureous acid. All the alkalis and earths decompoſe it, as do alſo all the mineral acids. It conſiſts of

Alumine, -	44
Sulphureous acid,	32
Water, -	24

NITRAT OF ALUMINE.

[In line 5th, p. 67.]

[p] A moderate heat decompoſes this ſalt, without decompoſing the nitric acid. It is always ſlightly acid, whatever may be the quantity of alumine employed to form it.

GLUCINE.

[At the end of Chap. IX.]

[q] Vauquelin has diſcovered a new earth in his analyſis of the beril, to which he has given the name of *glucine*, that ſeems to have many properties in common with alumine. The ſolution of this earth, however, in carbonic acid, does not, like that of alumine, afford alum by the addition of ſulphat of potaſh. This circumſtance induced Vauquelin to compare theſe two earths together, under a great many different points of view.

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* This note ought to have been inſerted in line 3d, page 66. The reader is requeſted to inſert the references to the following notes, which have been omitted in the text by accident.

Experiment 1. He diſſolved, ſeparately, equal quantities of alumine and the earth of beril in nitric acid to perfect ſaturation. The ſalt which reſulted from the combination of the earth of beril with nitric acid, did not ſeem to be ſuſceptible of cryſtallization, it powerfully retained its humidity, and, in drying, formed a kind of ductile paſte, which attracted humidity ſtrongly; when expoſed to the air, its taſte is very ſweet at firſt, and afterwards aſtringent.

2. Nitrat of alumine cryſtallizes alſo with difficulty, but it does not attract humidity with ſo much avidity; its taſte is not ſweet, like that of the nitrat formed with the earth of beril.

The nitrat of alumine, mixed with a ſolution of nut galls in alcohol, was not precipitated; the liquor acquired a ſlightly greeniſh colour, and loſt a little of its tranſparency. At the end, however, of ſome hours, a greyiſh precipitate was produced by diluting the liquor with water.

The nitrat of the earth of beril, mixed with the ſame reagent, afforded immediately a flaky depoſit of a brown yellow colour.

3. Nitrat of alumine, mixed with oxalat of potaſh, produced immediately a precipitate in the form of very copious white flakes, which collecting at the bottom of the veſſel, left the liquor quite clear.

4. The nitrat of the earth of beril, with the ſame reagent, did not exhibit the ſmalleſt appearance of a precipitate, even after ſome days.

5. Nitrat of alumine, mixed with tartarite of potaſh, occaſioned an immediate flaky depoſit, and the ſupernatant liquor became colourleſs.

6. Nitrat of the earth of beril, with the ſame reagent, exhibited no ſign of precipitation, even after ſeveral days.

7. Nitrat of alumine, mixed with a ſolution of phoſphat of ſoda, afforded a ſemi-tranſparent gelatinous precipitate, which was depoſited very ſlowly.

8. Nitrat of the earth of beril formed alſo a precipitate with the ſame reagent, but it was leſs gelatinous, and leſs tranſparent; it was alſo more ſpeedily depoſited.

9. Nitrat of alumine, mixed with very pure pruſſiat of potaſh, inſtantly afforded a very copious whitiſh precipitate, which became greeniſh at the end of ſome hours.

10. Nitrat of the earth of beril, with the ſame reagent, produced no precipitate even at the end of ſeveral days.

11. Nitrat of alumine, mixed with a ſaturated ſolution of potaſh, produced a gelatinous ſemi-tranſparent mixture, which was ſoon filled with a number of gaſeous bubbles that raiſed it to the top of the liquor.

12. Nitrat of the earth of beril afforded a flaky precipitate with the ſame reagent, which was not filled with bubbles like the former, and which fell to the bottom of the liquor.

13. Nitrat of alumine, mixed with a ſolution of cauſtic potaſh, afforded a gelatinous depoſit, which was diſſolved by an exceſs of alkali.

14. Nitrat of the earth of beril, treated with the ſame reagent, formed a ſimilar depoſit; but a greater quantity of alkali was neceſſary to diſſolve it.

15. Nitrat of alumine, mixed with a ſolution of carbonat of ammoniac, forms in it a precipitate which an exceſs of alkali does not diſſolve.

16. Nitrat of the earth of beril, mixed with the ſame reagent, gave alſo a precipitate; but an exceſs of alkali diſſolved it completely.

See *Ann. de Chem.* Tom XXVI. p. 155, 259.

NOTES ON CHAPTER X.

SULPHAT OF BARYTES.

[In line 22d, p. 72.]

[r] In the preparation of pure barytic earth, Vauquelin prefers the nitric to the muriatic acid. The nitrat of barytes is afterwards decompoſed by expoſure to the fire. If the earth obtained in this manner be uſed for the preparation of the muriat of barytes, it is better not to add to it directly the muriatic acid, but rather to decompoſe by it the muriat of ſoda. The muriat of barytes will cryſtallize, and leave the alkali in a ſtate of cauſticity, The alkali may be cryſtallized, by adding to it carbonic acid. *Journ. de Phyſ.* 1794, p. 297.

SULPHITE OF BARYTES.

[In line 20th, p. 73.]

[s] This ſalt does not cryſtallize. It has no ſenſible taſte, and is completely inſoluble in water. Neither is it, like the other earthy ſulphites, rendered ſoluble by exceſs of acid.

Fire changes it into a ſulphat. This effect is very ſlowly produced by the action of air.

It is not decompoſed by any alkali or earth.

Acids decompoſe it.

Alkaline carbonats are the only neutral ſalts which decompoſe it.

It conſiſts of

Barytes, -	59
Sulphureous acid,	39
Water, -	2

NITRAT OF BARYTES.

[In line 2d, p. 74.]

[t] Vauquelin remarks, that the taſte of this ſalt, like moſt of the combinations of barytes, is *piquant* and metallic. Its form is that of a particular octahedron. Ten or twelve parts of cold water are required to diſſolve it. Warm water diſſolves a much greater quantity, ſo that a great part of it cryſtallizes by cooling.

The decompoſition by heat affords barytes in a purer ſtate than by any of the ordinary proceſſes. In this ſtate the barytes is of a greyiſh colour, and has a cauſtic taſte, much ſtronger than that of lime. Cold water diſſolves 0,04 of its weight of this earth. Its ſolution, expoſed to the air, exhibits a pellicle like lime-water. It is rendered turbid by air expelled from the lungs, and forms a very copious precipitate with ſulphuric acid.

This ſolution, reduced in cloſe veſſels by evaporation to one-fourth of its volume, is not diſturbed, but affords, by cooling, very beautiful tranſparent cryſtals. Theſe cryſtals effloreſce when expoſed to the air, and acquire the property of efferveſcing with acids. The great ſolubility and eaſy cryſtallization of the barytes, are very remarkable.

This earth, expoſed to the air, is reduced to a powder, white, and extremely fine, which occupies a ſpace four or five times its original volume.

When we add a few drops of water to this earth, a ſtrong heat is inſtantly produced, vapours riſe, and the earth falls into a white ſhining powder of four or five times its original volume. If a ſufficient quantity be added to form a paſte, it becomes white, and ſwells; but it aſſumes, in cooling, the hardneſs of a ſtone. This method of obtaining barytes in a pure ſtate, is to be preferred to that of calcining carbonat of barytes.

Pruſſiat of potaſh, when added to a ſolution of this ſalt, produces an immediate decompoſition. But the nature of the ſalt which is formed, has not yet been examined. See *Journ. Polytech.* p. 380.

MURIAT OF BARYTES.

[In line 13th from the bottom of p. 75.]

u This ſalt is uſually prepared by decompoſing the ſulphure of barytes with muriatic acid; but as the ſulphat of barytes often contains oxyd of iron, the muriatic unites to it at the ſame time with the barytes, from which this ſalt receives a yellow colour. We ſeparate the oxyd eaſily, by expoſing it in a crucible to the fire for ſome minutes. When it begins to redden, the muriat of iron is decompoſed, its acid volatilized, and the oxyd remains mixed with the muriat of barytes, from which it may be ſeparated by ſolution in water.

This ſalt has a bitter and metallic taſte. It requires for its ſolution from five to ſix parts of cold water. It is more ſoluble in warm, and cryſtallizes by cooling.

The nitric acid alſo decompoſes the muriat of barytes. When a few drops of nitric acid are added to a concentrated ſolution of this ſalt, a cryſtallized precipitate is formed, which requires ten or twelve parts of water to diſſolve. Hence, in uſing muriat of barytes to diſcover whether nitric acid contains any ſulphuric, it is neceſſary to dilute theſe liquors properly, otherwiſe we may be apt to err, in attributing to the ſulphuric a precipitate which is produced by the combination of the nitric acid with barytes.

Oxalic acid produces the ſame effect. A cryſtalline depoſit is produced, which diſſolves in about twenty times its weight of water. Next to the ſulphuric it has the greateſt affinity. See *Journ Polytech.* p. 416.

This ſalt has of late years been uſed as a remedy againſt ſcrophula. Van Mons prepares it by the following proceſs: Equal parts of ſulphat of barytes, and ſaturated carbonat of potaſh, are mixed with 0,25 of water. This mixture is put into an earthen crucible, and heated till it melts. It is then to be withdrawn, and, when cool, pulverized and thrown into water. The reſidue of this maſs is put into twice its weight of rain water; it is then made to boil, and pure muriatic acid added till all effervefcence ceaſes. The liquor is then filtered, and the ſalt allowed to cryſtallize. The cryſtallization may be accelerated by heating the liquor, and by adding to it a few cryſtals of muriat of barytes. Van Mons varies this proceſs a little, when there is reaſon to ſuſpect that the ſulphat of barytes contains any metallic particles. To the mixture of ſulphat of barytes and potaſh he adds 0,07 of powder of charcoal. As ſoon as the mixture begins to redden, it is taken from the fire, and waſhed with water. It is afterwards boiled with a ſmall quantity of alkali, which forms a ſulphure with any of the ſulphur which may remain mixed with it. This being done, it is to be waſhed in warm water, ſaturated with muriatic acid, and cryſtallized. The carbon in this proceſs diſoxygenates the metallic particles, which are afterwards diſſolved and carried off by the alkaline ſulphure. See *Journ. de Phyſ.* 1794, p. 297.

CARBONAT OF BARYTES.

[In line 8th, p. 76.]

[w] When this ſubſtance, after having been long expoſed to the fire, is warmed with boiling water, and the ſolution filtered, the barytic earth ſhoots into ſmall cryſtals, ſome of which are evidently of an octahedral figure. This fact has been obſerved by Klaproth, Vauquelin, and Pelletier. See *Klaproth's Berträge*, ſ. 89.

This ſubſtance, like the carbonat of lime, becomes ſoluble by an exceſs of acid. The ſuper-ſaturated carbonat is an extremely uſeful ſubſtance in chemical experiments. It ſerves to precipitate the ſulphuric acid, by the inſoluble compound which it forms with it. It ſerves to purify the phoſphoric acid from the ſulphuric, and the carbonats of potaſh and ſoda from the ſulphat which they contain.

It is prepared with great care, by putting ſome carbonat of barytes, or, which is the ſame thing, barytes precipitated from muriatic acid by an alkaline carbonat, into a bottle of water impregnated with carbonic acid. The bottle is inverted, and the mixture left to digeſt in the cold for ſome hours. This ſolution is filtered, and kept in inverted bottles, to prevent the eſcape of the carbonic acid.

By digeſting ſome of the ſulphat of barytes in water impregnated with carbonic acid, Morveau obtained ſome carbonat of barytes with an exceſs of acid. He conceives that a ſmall portion of the carbonat is mixed with the ſulphat.

NEUTRAL SALTS, WITH BASE OF STRONTIAN.

[At the end of Chap. X.]

[x] As theſe ſalts have ſome properties in common with thoſe of the barytic genus, it may not be improper to exhibit a few of their principal characters.

SULPHAT OF STRONTIAN.

This ſalt, when formed by art, exiſts in the form of a white powder. It has no taſte, and very little ſolubility in water. Of one grain boiled for ſome minutes in four ounces of diſtilled water, only half a grain was diſſolved. The ſolution became turbid, by the addition of the carbonat of potaſh, and muriat of barytes. Sulphuric acid, when aided by heat, readily diſſolves it. An effuſion of water, however, cauſes the acid to part with the ſulphat of ſtrontian.

NITRAT OF STRONTIAN.

Cryſtallizes into octahedral cryſtals.

The nitrat of ſtrontian gives to the flame of alcohol a red colour.

This ſalt has a ſtrong pungent taſte. It is very ſoluble in water. An ounce of diſtilled water, at the temperature of 60°, diſſolved an equal weight. With the aid of a boiling heat, the ſame quantity diſſolved 1 ounce 7 drachms 14 grains. Nitrat of ſtrontian, in a dry air, loſes its water of cryſtallization; in a moiſt, it attracts humidity.

Like all other nitrats, it deflagrates on hot coals. Subjected to heat in a crucible, it decrepitates gently, and then melts. When the heat riſes to redneſs, it begins to boil, and the acid is diſſipated. If a combuſtible ſubſtance be brought into contact with it, a deflagration with a very beautiful vivid red flame is produced.

MURIAT OF STRONTIAN.

The cryſtals of this ſalt are ſlender delicate priſms, ſometimes two inches long, having a ſoft ſilky appearance. Theſe priſms are all hexagonal, ſome having all their ſides equal, others having two broad ſides, with two intervening narrow ones, while another ſort is ſeen with three broad, alternating with three narrow ſides. At one time they end abruptly, at another, an obtuſe trihedral pyramid terminates them, and now and then they are ſeen pointed like a needle. If a few drops of a ſolution of this ſalt be put on a plated glaſs, it will ſoon diſcover itſelf, by ſhooting into long ſlender needles, which are often diſpoſed in a riadiated form.

Theſe cryſtals, when ſtrongly dried, ſuffer little change from expoſure to air. They deliqueſce, however, in a moiſt atmoſphere. At the temperature of 60°, an ounce of diſtilled water is capable of diſſolving 1 ounce 4 drachms and 1 ſcruple of this ſalt. The ſolubility of muriat of ſtrontian is greatly increaſed by heat.

It is ſoluble alſo in rectified ſpirit of wine, and communicates to it the property of burning with a dark red flame.

If ſtrong muriatic acid be added to a ſaturated ſolution of this ſalt, an immediate precipitation is produced.

The taſte of this ſalt is ſharp and penetrating. It loſes 42 per cent. by expoſure to a ſtrong fire, and is converted into a white powder, which melts when the crucible is heated to redneſs. Its acid is not diſſipated by fuſion in a ſtrong fire, though this effect may be produced by expoſing it to the ſtronger heat of a blowpipe.

FLUAT OF STRONTIAN.

When fluoric acid is added to a ſolution of ſtrontian in water, a white powder falls to the bottom, which is fluat of ſtrontian. The properties of this ſalt, which is not very ſoluble in water, have hitherto been but little inveſtigated.

BORAT OF STRONTIAN

Seems to be but very ſparingly ſoluble in cold water. It requires about 130 times its own weight of boiling water to diſſolve it. The ſolution changes to a green, the colour of paper ſtained with the juice of violet. This ſalt has alſo been but little examined.

CARBONAT OF STRONTIAN.

Strontian, a ſubſtance very ſoluble in water, becomes ſcarcely ſo by uniting with carbonic acid. With an exceſs of this acid its ſolubility is increaſed like that of lime or barytes. Its taſte is inſipid. It is diſſolved with efferveſcence, by a great number of acids. Carbonat of ſtrontian has been found to contain about 30 per cent. of carbonic acid. This acid can be expelled from it only in a very violent fire. It acquires by this an acrimonious taſte, and diſſolves readily in water. When a little water is poured on it in this ſtate, it ſwells, burſts with a hiſſing noiſe, and becomes hot like lime.

POINTS OF DIFFERENCE BETWEEN BARYTES AND STRONTIAN.

Native carbonat of ſtrontian has a ſhade of clear green, which that of barytes has not. It requires more muriatic acid to diſſolve it; it contains more carbonic acid. Muriat of ſtrontian cryſtallizes by cooling, while that of barytes cryſtallizes by evaporation. The cryſtals of the former are priſms with ſix ſides, the latter are plates bevelled at the edges. The ſolution of muriat of ſtrontian is converted into a jelly by evaporation, while muriat of barytes dries in cryſtallized plates. The former, which is very ſoluble in alcohol, burns in it with a beautiful blue flame; the latter, which is almoſt inſoluble in that fluid, gives to it a yellow flame.

The greateſt and moſt remarkable difference which exiſt between the ſtrontian and barytes, is the weaker affinity which the ſtrontian has for acids than barytes, and even alkalis have, ſo that the ſolution of barytes precipitates the muriat of ſtrontian in white flakes.

Nitrat of ſtrontian differs from that of barytes, 1ſt, In giving out more nitrous gas during its decompoſition by fire, the nitric acid adhering leſs ſtrongly to it than to the barytes; and, 2dly, In being three times more ſoluble in water.

Strontian earth obtained from the nitrat by means of fire, is leſs acrid than barytes; it does not melt, like barytes, with the blow-pipe, but ſhines with a phoſphoric flame. It is nearly ten times leſs ſoluble in water; its affinity appears to be weaker than that of lime, ſince it does not ſeparate it from acids. When precipitated by oxalic acid, it does not diſſolve in an exceſs of that acid, like barytes. Sulphat of ſtrontian, on the contrary, is ſoluble in an exceſs of ſulphuric acid, while ſulphat of barytes is inſoluble. The ſolution of ſtrontian in water is not precipitated with the gallic acid, while that of barytes gives with that a greeniſh precipitate. See *Klaproth's Berträge. Dr. Hope, Edin. Phil. Tranſ. Pelletier, Ann. de Chem.* Tom. XXI. p. 113. *Fourcroy* and *Vauquelin*, p. 276.

NEUTRAL SALTS, WITH BASE OF ZIRCONIA.

[At the end alſo of Chap. X.]

[y] Zirconia combines with acids, and forms ſalts, ſome of which are ſoluble, and others very inſoluble in water. To the ſoluble belong the ſulphat, ſulphite, phoſphat, phoſphite, fluat, borat, carbonat, oxalat, citrat, tartarite, gallat, ſacolactat, and to the inſoluble, the nitrat, muriat, acetat, acetite, benzoat and malat.

In order that the combination of the zirconia may be readily produced, it is neceſſary that this earth be very much divided, and ſtill humid, ſuch as it exiſts when newly precipitated from its ſolvents. It enters into theſe combinations very difficultly after it has been dried in the fire, or even in the heat of an ordinary ſtove. This earth adheres weakly to acids, for the action of even a low heat is ſufficient to deſtroy its combination. This is alſo ſhown by its yielding its acids to the alkalis and to all the other earths. The neutral ſalts, with zirconia, have a very conſiderable aſtringent taſte, reſembling greatly that of many metallic ſalts.

SULPHAT OF ZIRCONIA.

Sulphuric acid and zirconia unite readily. The ſalt which reſults from this combination is white, inſoluble in water, and without any ſenſible taſte. Heat decompoſes it, and leaves the zircon pure. It is not affected by acids, but alkalis and earths decompoſe it. Carbon converts it in a high temperature into a ſulphure, which is ſoluble in water; and this ſolution affords by evaporation cryſtals of *hydro-ſulphure* of zircon.

NITRAT OF ZIRCON.

The nitric acid alſo combines with zircon, when it is in the humid ſtate. It is impoſſible, however, to ſaturate the nitric acid with this earth, ſo as to deſtroy its acid properties, for the nitrat of zircon always changes the blue infuſions of vegetables in the ſame manner with acids.

The ſolution of nitrat of zircon, when evaporated by a gentle heat, affords a yellowiſh tranſparent, extremely tenaceous and viſcous matter, which can be dried only with great difficulty. This ſalt has a ſtyptic and aſtringent taſte, and leaves a thick matter on the tongue, which is produced from a decompoſition occaſioned by the ſaliva. Nitrat of zircon diſſolves only in a very ſmall quantity in water. To obtain it in a ſtate of cryſtallization, it is neceſſary to evaporate it in a very gentle heat, or by ſimple expoſure to the air. Zirconia has the weakeſt affinity of all known earthy ſubſtances for acids.

The nitrat of zircon is decompoſed by ſulphuric acid, which forms with it a white precipitate, ſoluble in an exceſs of that acid; 2dly, By carbonat of ammoniac, which produces in it a depoſit ſoluble in an exceſs of that ſalt; 3dly, By an infuſion of galls in alcohol, a white precipitate is produced, ſoluble in an exceſs of the infuſion; but if the zircon contains iron, the precipitate is of a blue colour, approaching to grey, a portion of which remains in ſolution, and gives to the liquor a pure blue colour. This liquor, when mixed with carbonat of ammoniac, affords a matter purple with refracted, and violet with reflected rays. Cryſtallized gallic acid precipitates alſo the nitrat of zircon, of a blueiſh grey colour; but this colour is not ſo beautiful. The greater part of the vegetable acids take zircon from the nitric, and form with it inſoluble compounds.

MURIAT OF ZIRCON.

The muriatic acid unites readily with zircon, when it is divided or combined with carbonic acid, but it becomes incapable of combination with it after this earth has been brought to a ſlight red heat in the fire.

Muriat of zircon has no colour. Its taſte is aſtringent; it is very ſoluble, and diſſolves equally well in alcohol, to the flame of which it does not communicate any particular colour. The muriatic acid is expelled by heat. This ſalt forms concretions in the mouth in conſequence of being decompoſed by the ſaliva. The ſolution of this ſalt affords, by a careful evaporation, ſmall tranſparent needle-like cryſtals, of a form difficult to be determined. This ſalt loſes its tranſparency in the air, by giving out a portion of its water of cryſtallization. When muriat of zircon contains ſome portions of ſilex, cubical cryſtals are produced, which have a conſiſtence reſembling that of a jelly. Theſe cubical cryſtals, when expoſed to the air, gradually loſe their tranſparency, and ſuffer a diminution of volume. White and ſilky needles are at the ſame time formed in the maſs of this ſalt, which project beyond the cubes from which they take their riſe. The affinity of the muriatic acid for zircon, is the ſame with the nitric, ſo far as earths and alkalis are concerned.

Muriat of zircon is decompoſed, 1. By ſulphuric acid. A part of the ſulphat of zircon which is formed, is precipitated in the form of heavy white flocks, while another portion is retained in ſolution by the muriatic acid. But if this acid be diſſipated by heat, the remaining portion of the ſulphat of zircon is gradually depoſited, and if the evaporation of the liquor be ſtopped before that is reduced to dryneſs, it forms a kind of jelly by cooling. The ſulphat of zircon is therefore ſoluble in muriatic acid; and this ſolubility is increaſed by means of caloric.

2. The phoſphoric, citric, tartarous, oxalic, and ſacolactic acids decompoſe the muriat of zircon, and form with its baſe inſoluble compounds, which are precipitated in the form of white flocks.

3. The gallic acid precipitates the muriat of zircon in the form of a white matter, or in that of a greyiſh green, if it contain iron. In the latter caſe the depoſit acquires, by drying, a ſhining black colour, like that of China-ink. The liquor in which the gallats of zircon and iron have been formed, preſerves a greeniſh colour, and though freſh quantities of gallic acid do not occaſion any more precipitation, the carbonat of ammoniac ſeparates a very copious flocky matter, which has a purpliſh colour, ſimilar to that of lees of wine.

Theſe experiments prove, 1ſt, That the gallic acid has a greater affinity with zircon than the muriatic acid poſſeſſes, and that the gallats of zircon and iron are ſoluble in muriatic acid, ſince a part of them remained in ſolution in the liquor which was ſeparated by carbonat of ammoniac.

2. Carbonat of potaſh, ſaturated with carbonic acid, precipitates zircon from its ſolution in muriatic acid; and though this ſolution be made with effervеſcence, the precipitate, when waſhed and dried in the air, retains a large portion of carbonic acid, for this earth afterwards produces a lively effervеſcence, when diſſolved in acids.

3. A ſolution of ſulphurated hydrogen gas in water, mixed with a ſolution of muriat of zircon containing iron, diſturbs the tranſparency of the ſolution, and gives to it a reddiſh colour; but it does not occaſion a true precipitate. The hydro-ſulphure of ammoniac inſtantly precipitates this ſalt of a beautiful green colour, which becomes black when dry. This precipitate, when placed on burning coals, gives out the ſmell of ſulphurated hydrogen gas, and becomes of a blueiſh ſlightly purpliſh colour by pulverization, before that it has been heated it affords a powder of a pearl grey colour. This colour is owing to the oxyd of iron combined with the zircon.

4. The carbonat of ammoniac produces at firſt a depoſition in muriat of zircon, but freſh quantities of the ammoniacal ſalt rediſſolve the greater part of the precipitate. In this caſe a triple ſalt is formed, which may be decompoſed by heat.

5. The pruſſiat of mercury produces in the ſolution of muriat of zircon, a very copious precipitate, ſoluble in muriatic acid. This depoſition cannot be owing to

the combination of the mercury with the muriatic acid, for none of the ſalts into which it enters forms a precipitate with the pruſſiat of mercury. Were we even to ſuppoſe this caſe to be an exception, ſtill the depoſition would not be ſoluble in ſimple muriatic acid.

6. A plate of zinc, introduced into a ſolution of muriat of zircon, occaſions a ſlight effervеſcence, owing to the diſengagement of hydrogen gas. The liquor becomes milky, and at the end of ſome days aſſumes the form of a white ſemi-tranſparent jelly.

7. Pure alumine decompoſes the muriat of zircon, by the aſſiſtance of a ſlight heat. The alumine is diſſolved, the liquor becomes milky, and aſſumes a gelatinous form by cooling. When the muriat of zircon contains iron, it remains in ſolution along with the alumine, ſo that the zircon which is precipitated does not contain any ſenſible quantity of that metal. See *Klaproth's Berträge. Vauquelin, Ann. de Chem.* Tom. XXII. p. 179.

PART II.

MINERALOGY.

SECTION III.

COMBUSTIBLE BODIES.

CHAPTER I.

CONCERNING COMBUSTIBLE BODIES IN GENERAL.

WE have already ſpoken of combuſtion in the hiſtory of air. The order we have adopted requires a ſhort recapitulation in this place of the doctrines there maintained.

A combuſtible body, according to Stahl, is a compound which contains fixed fire or phlogiſton; combuſtion, according to his theory, conſiſts in its diſengagement, and its tranſition to the ſtate of liberty; which are manifeſted by light and heat. When this proceſs is entirely finiſhed, the body enters the claſs of incombuſtible matters, and may regain its original combuſtibility by receiving its phlogiſton, or by becoming again united to the matter of fire transferred to it from another body. We have taken notice of four principal difficulties in this theory: 1. The impoſſibility of aſcertaining the preſence of phlogiſton. 2. The augmentation of weight by combuſtion, which cannot be imagined to ariſe from the loſs of a principle. 3. The loſs of weight which a body ſuſtains when it paſſes from the incombuſtible to the inflammable ſtate, by the addition of phlogiſton. 4. The little attention Stahl paid to the neceſſity of air in combuſtion.

A more accurate obſervation of this laſt phenomenon, and the augmentation of weight which combuſtible bodies acquire by being burned, has given birth to the following theory.

Bodies are combuſtible, becauſe they tend ſtrongly to combine with the baſe of vital air or oxygen, and combuſtion is the proceſs by which this combination is effected. It takes place only in proportion as the oxygen loſes the caloric which maintained its aerial ſtate. The four following facts conſtitute the baſis of this opinion. 1. Bodies cannot burn without air. 2. The purer the air, the more rapid the combuſtion. 3. By combuſtion air is abſorbed, and the weight of the burned body augmented. 4. Laſtly, The body burned in the atmoſphere contains the portion of oxygen which the atmoſphere loſt; and this portion may in ſome caſes be extracted by different methods hereafter to be deſcribed.

Macquer united this theory with that of Stahl, by conſidering fixed light as phlogiſton, and admitting vital air as the precipitant of light. He ſuppoſed that in every combuſtion the phlogiſton was ſeparated, in the form of light, by the vital air which occupied its place in the combuſtible body; and he conſidered theſe two ſubſtances, light and vital air, as mutual precipitants of each other. So that when fixed light paſſes from a combuſtible body into a body already burned, he ſuppoſed that this tranſition is made only in proportion as the vital air united with the burned body gives place to the matter of light, and becomes itſelf transferred into the other ſubſtance from which the light eſcapes. The ſtrict and accurate form which the modern doctrine has for ſome years acquired, does not either require, or even permit, our having recourſe to complicated and forced theories: by referring to it in this place, we only add to the perſpicuity and clearneſs of our enunciation.

Vital air is compoſed of a fixable baſe, called oxygen, held in ſolution in the ſtate of elaſtic fluidity by the matter of fire or light. When a combuſtible body is heated in this fluid, it decompoſes the vital air by ſeizing its oxygen; the matter of fire being at the ſame time ſet at liberty, and eſcaping with the appearance of its diſtinguiſhing characters, namely, heat and light, which conſtitute flame. According to this hypotheſis, vital air is the true and only combuſtible body. This theory does not ſeem to reject the preſence of phlogiſton, which is here exhibited in the form of light; but it differs from that of Stahl, by the place allotted to phlogiſton or fixed fire, which we admit in the body which maintains the combuſtion; while Stahl imagined it to exiſt in the combuſtible body. The ſame objection may likewiſe be made againſt the oxygenous principle of vital air, as has been urged againſt the phlogiſton of Stahl. In fact, this principle has not yet been exhibited in an inſulated or pure ſtate, ſince it always exiſts, either combined with caloric in vital air, or with combuſtible bodies after they have been burned. Like phlogiſton, it is only perceived to paſs from one body to another, and to change its combination, without being capable of a ſeparate exhibition in a ſtate of purity; nevertheleſs, there is a great difference between the two theories; the latter (which we admit) poſſeſſes all the characters of accuracy and truth; it is founded on the addition and ſubtraction of weight, which could never be done in the doctrine of Stahl.

The different combuſtible bodies vary greatly in their reſpective tendency to combine with oxygen; and the greater or leſs degree of combuſtibility appears to depend on theſe variations: ſo that a table of the order of their combuſtibility or affinity with vital air may be hence conſtructed.

This variety of affinity between combuſtible bodies and oxygen, is the cauſe of the different phenomena they preſent during their combination with that fluid: four kinds of combuſtion may therefore be diſtinguiſhed.

1. Combuſtion attended with flame and heat, ſuch as, for example, the combuſtion of ſulphur.

2. Combuſtion attended with heat, but without flame, as that of ſeveral metals.

3. Combuſtion with flame, but without heat, as that of phoſphorus, &c.

4. Slow combuſtion, without apparent heat or flame, ſuch as takes place by the contact of certain combuſtible bodies with air, or when the oxygen fixed in a body, and deprived of caloric, paſſes tacitly from that body to another.

It muſt be obſerved, that the phenomena of combuſtion differ likewiſe in many other reſpects, peculiar to each combuſtible body. The rapidity, colour, and magnitude of the flame; the ſmell which accompanies it; the quantity of oxygen abſorbed; the form, the colour, the weight, and other properties of the reſidue; together with other concomitant circumſtances, which it is needleſs to explain in this place, becauſe they will be treated with that attention which the importance of the ſubject demands, in the account of each combuſtible body, ſerve to eſtabliſh eſſential differences, well adapted to characterize bodies belonging to this claſs.

When we conſider the great variety of phenomena exhibited by combuſtible bodies, we cannot but admit that the cauſe of this phenomenon is ſtill unknown, and that important diſcoveries remain to be made in this part of chemical theory. The different degrees of affinity which appear to exiſt between combuſtible bodies and oxygen, are already ſufficient to account for ſome of the facts. It is natural to believe, that a body, which has a ſtrong attraction for this principle, will exhibit more heat, motion, and light; becauſe this laſt will be ſeparated with more energy. But this doctrine does not explain the cauſe of the various colours of flame in combuſtible bodies; why, for example, copper burns green, &c.; neither does it explain, at leaſt in the way of experiment, how certain bodies burn without apparent flame, unleſs we adopt the opinion of many philoſophers, that the matter of light and of heat are one and the ſame, and differ only in the degree of condenſation. The difficulties attending this opinion are ſufficiently known. If it could be proved, that light is combined in combuſtible bodies, and that it is diſengaged during combuſtion, it might be imagined, that this ſubſtance is differently combined in different bodies: that in ſome, for example, the whole of its ſeven rays, or principles, is fixed; that others contain only the orange-coloured ray, as nitrous gas; and others the yellow or green, as zinc and copper. But this hypotheſis, which has already been mentioned in the hiſtory of combuſtion, when treated of under the article *Air*, has not yet been confirmed by facts. It is ſufficient that it is almoſt demonſtrated that the light is contained rather in the vital air than in the combuſtible body. In fact, how can we conceive, that a body ſo divided, and ſo elaſtic, as light, can become fixed and ſolid? Is it not more natural, and conformable to the notions of ſound philoſophy, to conclude, that, far from being capable of aſſuming the ſolid form, light is rather adapted to deſtroy it in ſuch bodies as poſſeſs it, and that it is one of the cauſes of the elaſticity of vital air, which is merely oxygen, naturally ſolid, united with caloric and light?

It appears therefore, that difficulties ſtill remain to be cleared up in the hiſtory of combuſtion; but that it is well eſtabliſhed, that combuſtible bodies, after having been burned, acquire a different nature, becoming more heavy by the addition of the oxygenous principle; and that this principle has aſſumed a more ſolid form than it before poſſeſſed, when combined with caloric and light, in the ſtate of vital air.

We ſhall divide mineral combuſtible bodies into five genera; namely, diamond, hydrogen or inflammable gas, ſulphur, metallic ſubſtances, and bitumens.

CHAPTER II.

GENUS I. DIAMOND.

DIAMOND is a ſingular ſubſtance; it is uſually reckoned among ſtones, becauſe of its hardneſs, inſipidity, and inſolubility: it is, beſides, the moſt tranſparent and the hardeſt of all minerals. This hardneſs is ſuch, that the beſt tempered ſteel has no effect on it; and it can only be worn away by rubbing one diamond againſt another. This is called grinding.

Diamonds are found in the Eaſt Indies, particularly in the kingdoms of Golconda and Viſapour: they likewiſe come from the Brazils; but theſe laſt appear to be of an inferior quality, and are known in commerce by the name of Portugueſe diamonds.

Diamonds are uſually found in an ochreous yellow earth, under rocks of grit-ſtone and quartz; they are likewiſe found detached in torrents, which have carried them from their beds. Diamonds are ſeldom found above a certain ſize. The ſovereigns of India reſerve the largeſt, in order that the price of this article may not fall. Diamonds have no brilliancy when dug out of the earth, but are covered with an earthy cruſt, which encloſes a ſecond cruſt, of the nature of calcareous ſpar, according to Romé de Lille. Bright diamonds are occaſionally found in waters.

Diamonds very often have no regular form, but are flat, or worn round. Sometimes they are regularly cryſtallized in octahedrons, formed by two quadrangular pyramids, united at their baſes; they are likewiſe found with twelve, twenty-four, and forty-eight faces.

Some diamonds are perfectly tranſparent; others are ſpotted, veined, clouded, and are of much leſs price. Some are uniformly and beautifully tinged with yellow, red, blue, and black; the latter are very rare.

Diamonds appear to be compoſed of laminæ, laid upon each other; and they are eaſily divided, by ſtriking them in the direction of theſe laminæ with a good ſteel inſtrument. There are, however, ſome diamonds which do not appear to be formed of diſtinct laminæ, but of twiſted fibres, like thoſe of knots in wood. Theſe laſt are exceedingly hard, and cannot be wrought; lapidaries call them diamonds of nature.

The tranſparency, the hardneſs, and the regular cryſtalline form of the diamond, induced naturaliſts to claſs it among vitrifiable ſtones. They conſidered it as the pureſt and moſt homogeneous rock-cryſtal. They ſuppoſed it unchangeable by fire, becauſe jewellers are in the habit of heating, and even of igniting, diamonds ſpotted with yellow; the ſpots becoming black by this proceſs, and incapable of affecting the brilliancy of the reſt of the ſtone. It was nevertheleſs known, that diamond is much heavier and harder than rock-cryſtal, and that it poſſeſſes a ſtrong electric property; but theſe were attributed to its extreme purity.

It is known, that all earthy or ſaline bodies refract the light nearly in the direct ratio of their denſity, but that tranſparent combuſtible bodies refract it about twice as much. The diamond produces nearly three times the refraction it would have produced, according to the ratio of its denſity; and as the refraction of light, from the poſterior ſurfaces of bodies, is greater in this ratio, the ſingular luſtre of the diamond muſt depend on this property. As it is exceedingly tranſparent, and the light is ſtrongly refracted and reflected by its ſurfaces, every one of the facets emits a very brilliant pencil of light. For which reaſon, ſuch diamonds as are cut into facets on every part of their ſurface, emit a much ſtronger light than ſuch as are cut only on one ſide; whence the lapidaries diſtinguiſh the firſt by the name of brilliants, and call the ſecond roſes.

Boyle affirmed, that fire altered diamonds, and diſengaged acrid vapours; but the fact firſt mentioned by this philoſopher was not attended to. However, Coſmo the Third, Grand Duke of Tuſcany, in the years 1694 and 1695, ſaw diamonds deſtroyed, at Florence, by the burning mirror; and many years afterwards, the Emperor Francis I. was a witneſs of their deſtruction by the ſimple fire of a furnace.

D'Arcet, in his valuable experiments on the deſtruction of ſtony ſubſtances, expoſed to the heat of a violent and long continued fire, did not forget the diamond. He aſſerted, that it is evaporated in the direction of its laminæ, and that if the evaporation be deſignedly interrupted, the remainder is not at all altered, but conſiſts of a diamond of leſs magnitude.

D'Arcet, being deſirous of determining whether the evaporation of the diamond be any thing elſe but a ſimple decrepitation, thought proper to treat them in veſſels, cloſed by various methods. He took a ſphere of porcelain clay, and after having cut it in two, he placed a diamond in the centre, and then cloſed the two hemiſpheres together, in ſuch a manner, as that the diamond formed its own bed in the clay, without any other cavity. This ſphere, being placed in the furnace till it was baked, was then broken, and the diamond was found to be evaporated, the ſpace in which it was lodged being empty, without the leaſt perceptible crack in the ball.

D'Arcet varied this experiment, by ſometimes uſing balls of porcelain clay, and at other times baked crucibles of porcelain, cloſed with a ſtopper of the ſame ſubſtance, covered with a fuſible matter, which, vitrifying in the fire, formed an hermetical cloſure. D'Arcet always found that the diamond diſappeared, and concluded that it is evaporable without the acceſs of air.

D'Arcet and Roux have ſince obſerved, that it is not neceſſary to uſe ſo violent a heat to volatilize diamonds; and in the year 1770, Roux volatilized one, at the School of Medicine, in five hours, in a cuppelling furnace.

In the year 1771, Macquer obſerved a new phenomenon relative to the deſtruction of this ſubſtance. Having a diamond to volatilize, he uſed the furnace of Pott, with ſome improvements of his own. This furnace, with the addition of a tube, or chimney, of ten or twelve feet in height, produces a degree of heat equal to that of a furnace for hard porcelain. Macquer, having placed a muffle in the centre of this furnace, which at that time had only two feet of chimney, put a brilliant cut diamond, weighing three-ſixteenths of a carat, in a cuppel, which he firſt placed near the mouth of the red hot muffle, into which he gradually removed it, that the diamond might not fly in pieces by the too ſudden heat. At the end of twenty minutes, having obſerved the diamond, he found it increaſed in volume, and much more brilliant than the capſule in which it was placed; and laſtly, he obſerved a light, and apparently phoſphoric flame, forming a very evident glory round the ſtone; but he perceived no acrid vapours, as Boyle mentioned. The diamond having been replaced under the muffle, entirely diſappeared at the end of thirty minutes, without leaving any trace behind. Macquer, therefore, volatilized, in leſs than an hour, a diamond weighing near four grains, and found that it burned with a ſenſible flame, in the ſame manner as other combuſtible bodies.

This fact, publiſhed by Macquer, has been verified ſeveral times ſince. In the year 1775, Bucquet volatilized a diamond of about three grains and a half. He uſed the furnace of Macquer, but without the chimney; and the muffle remained open almoſt the whole time of the operation, in order to obſerve what paſſed during the combuſtion of the diamond. It remained about fifteen minutes before it inflamed, and in leſs than twenty-five minutes afterwards it was entirely diſſipated.

None of theſe experiments proving what became of the diamond, Macquer, Lavoiſier, and Cadet, reſolved to make ſome experiments in cloſe veſſels. They diſtilled twenty grains of diamonds in a ſtone-ware retort, with a proper apparatus for collecting the product, if any paſſed over. A fire of the greateſt violence was uſed, and nothing was obtained. The diamonds was found entire, but had loſt ſome of their weight. It was therefore ſuſpected, that this loſs depended on the diamonds having been partly burned, by means of a ſmall quantity of air included in the veſſels. The diamonds were, beſides, covered with a blackiſh and coaly film, which was quickly taken off by the mill.

While theſe chemiſts were buſied in reſearches into the nature of diamond, the lapidaries ſtill retained their belief of its abſolute indiſtructability by fire. One of them, Le Blanc, brought a diamond to Rouelle to be expoſed to the fire, but choſe to encloſe it in his own way. He placed it in a crucible, with a cement of chalk and powder of charcoal. This crucible was encloſed in another, with a cover, and luted. It remained in the fire during four hours, as well as ſeveral other diamonds, on which Rouelle was making experiments. At the end of this time, the diamonds of Rouelle, as well as that of Le Blanc, were found to have diſappeared. Maillard, another lapidary, waited on Cadet, with whom Macquer and Lavoiſier were then at work; he produced three diamonds, which he propoſed to expoſe to the fire, cemented in his own way.

He filled the bowl of a tobacco pipe with pounded charcoal, well preſſed in, the diamonds being placed in the centre; he covered the pipe with an iron plate, luted on with founders ſand. The pipe was included in a crucible, ſurrounded with chalk, and covered with a bed of ſand, moiſtened with ſalt water. The whole was placed in Macquer's furnace, and the heat ſo raiſed, that at the end of two hours it appeared ſoftened, and ready to melt. After the operation, the crucible was found to be vitrified, and had loſt its figure; it was broken with care, and the pipe was found perfectly whole, the charcoal as black as ever, and the diamonds not at all diminiſhed in weight. They were only blackened on their ſurface, and became white and brilliant by friction on the mill. Macquer repeated this experiment, with equal ſucceſs, in the large furnace, in which the hard porcelain of Seve is baked; yet, as the iron which covered the pipe was melted, and part reached the diamond, it was ſcorified on that ſide, but the other ſide remained perfect. The fire laſted twenty-four hours.

Mr. Mitouard having had opportunities of treating many diamonds in cloſed veſſels, and with different cements, found that charcoal is the moſt effectual in preventing the deſtruction of this body.

All chemiſts were convinced, from theſe facts, that the diamond burns in the ſame manner as other combuſtible bodies, and like charcoal is not deſtroyed, but in proportion to the contact of air. Neverthelefs, the well conducted and accurate experiments of D'Arcet ſeem to ſhow the contrary. To clear up this matter, Macquer filled ſeveral balls of baked porcelain and ſeveral crucibles of unbaked porcelain clay, with powder of charcoal; the charcoal was reduced to aſhes, and the aſhes even became vitrified in the unbaked veſſels, while that in the baked veſſels remained unchanged. Whence this chemiſt concluded, that there is a great difference between theſe two kinds of veſſels; he thinks that cracks are made during the baking of the porcelain, which are ſufficient to facilitate the combuſtion, though they afterwards diſappear by the contraction of the porcelain in cooling.

Lavoiſier has made other experiments, which prove, that diamond does not burn, but in proportion to the quantity of air it is in contact with. He expoſed diamonds to the focus of Mr. Tradaine's lens, after having covered them with a bell, under which he cauſed water or mercury to riſe by extracting the air. This chemiſt, in his experiments on the effects of the burning glaſs made together with Macquer, Cadet, and Briſſon, had already obſerved, that if diamonds be ſuddenly heated, they ſplit and fly about very ſenſibly; but that this does not happen when they are ſlowly and gradually heated. He likewiſe obſerved, that the diamonds melted and flowed in certain parts. The ſurface of thoſe which remained a certain time expoſed to the focus of the lens, appeared full of little cavities like a pumice-ſtone. By heating them in the ſaid pneumato-chemical apparatus he aſcertained that the diamond burns only for a certain time, proportioned to the quantity of air contained under the veſſel; and that the air, after the combuſtion of the diamond, is abſolutely ſimilar to that which remains after the combuſtion of other inflammable bodies; that is to ſay, deprived of the portion of vital air required to maintain that proceſs. It muſt be noted, that this reſidual air, after the combuſtion of the diamond, contained carbonic acid, as appeared by its precipitating lime-water.

To ſhow ſtill more evidently the nature of the diamond, Lavoiſier attempted to burn it under glaſs veſſels filled with carbonic acid. The diamond ſuffered a ſmall loſs, doubtleſs owing to a portion of air mixed with this acid. This chemiſt thinks, that great part of the loſs likewiſe depends on the volatilization of the diamond; and he thinks that this ſtone might be entirely ſublimed in cloſe veſſels, if a ſufficient degree of heat could be applied. Lavoiſier having made the ſame experiments on charcoal, found the ſame events take place, both with reſpect to combuſtion and volatilization. He likewiſe obſerved, that the diamond always became black at its ſurface.

From theſe different facts it follows, that the diamond is a ſubſtance not at all reſembling ſtones; but is on the contrary a true combuſtible body, capable of burning with a flame, whenever it is ignited with contact of air. In a word, that it is a true combuſtible volatile ſubſtance, which leaves no fixed reſidue; perfectly reſembling charcoal by its habitudes in the fire, though greatly differing from that ſubſtance in tranſparency, weight, hardneſs, and many other properties. All theſe experiments, as well as the art of ſplitting the diamond, ſhow that it is formed of laminæ placed one on the other; that there is ſometimes between the layers a foreign colouring matter, which perhaps cauſes the carbonaceous film, with which diamonds become covered when heated, eſpecially in cloſe veſſels. This coloured ſtratum, being placed at different depths, may be the cauſe why the proceſs uſed by lapidaries to render clouded diamonds tranſparent, does not always ſucceed. If its depth be inconſiderable, it may be eaſily deſtroyed, and the diamond will become clear. If, on the contrary, it be far within the ſtone, it cannot be removed but by the ſucceſſive deſtruction of the laminæ placed over it, which in that caſe would require the diamond to be almoſt entirely deſtroyed before the imperfection could be removed. Notwithſtanding all theſe experiments, we are ſtill unacquainted with the compoſition of the diamond; and in the preſent ſtate of our knowledge muſt conſider it as a peculiar combuſtible body different from all others [a].

The diamond is of little uſe but as an ornament; but its property of refracting the rays of light, decompoſing them, and exhibiting the moſt lively and brilliant colours, renders it truly precious without the aſſiſtance of the caprice of faſhion. Its exceſſive hardneſs, by which its exquiſite poliſh remains unalterable, its rarity, and the labour of cutting it, add ſtill to its value. It is advantageouſly uſed to engrave on glaſs and hard ſtones, or to cut them into convenient ſizes.

Diamond powder is uſed in poliſhing diamonds.

CHAPTER III.

GENUS II. HYDROGEN GAS.

THE gas called *inflammable air* by Dr. Prieſtley, and which we name *hydrogen gas*, is an elaſtic fluid, poſſeſſing all the apparent properties of air. It is about thirteen times lighter than the air of the atmoſphere, does not maintain combuſtion, and quickly deſtroys animal life by producing ſtrong convulſions. It has a very evident and peculiar ſmell. One of its characteriſtic properties is to take fire when in contact with air, by the application of a body already ignited, or by the electric ſpark.

Hydrogen gas has been long known, as a product both of nature and art. Mines, coal-pits, the ſurface of waters, and putrified animal or vegetable ſubſtances, exhibited a great number of inſtances of vapours naturally combuſtible; and vapours of the ſame nature have long been artificially produced, in the ſolution of ſeveral metals in the ſulphuric and muriatic acids, and in the diſtillation of animal and vegetable ſubſtances. But no one before Dr. Prieſtley thought of collecting them in receivers, and examining their properties. This philoſopher diſcovered, that they conſtitute a kind of permanently elaſtic fluids.

Hydrogen gas exhibits all the phenomena of combuſtible bodies, in a moſt eminent degree. Like them, it cannot be burned without acceſs of air. Its flame is more or leſs red when pure, and blue or yellow when it is united to a ſubſtance capable of modifying its properties. It frequently crackles, and produces ſmall brilliant ſparks during its combuſtion, with a noiſe ſimilar to that of nitre, when it detonates. A ſtrong heat is excited during its combuſtion. It is inflamed by the electric ſpark.

It burns more rapidly, in proportion as it is environed with a larger quantity of air. As theſe two fluids have a like aggregation, it is poſſible to mix them in ſuch a manner, as that every particle of each ſhall be contiguous to a particle of the other, in which caſe it will burn with great rapidity. This is evident, when a mixture of two parts of atmoſpheric air, and one of hydrogen gas is ſet on fire: the combuſtion is inſtantaneous, and attended with a ſtrong exploſion, reſembling that of gunpowder; whereas hydrogen gas, not mixed, but expoſed to common air, when ſet on fire, burns gently, and at the ſurface.

It may in the ſame manner be burned in an inſtant, and with much more vehemence, if two or three parts be mixed with one of vital air or oxygen gas: the exploſion is then much more conſiderable than in the foregoing experiment.

Mr. Cavendiſh, many years ago, remarked, that whenever hydrogen gas is burned, drops of water are always produced. Hydrogen gas being burned in a veſſel full of vital air, over mercury, a vacuum is produced in the apparatus; the mercury riſes, and the ſides of the glaſs are covered with a large quantity of drops of very pure water, which increaſe in proportion as the combuſtion goes on. Lavoiſier in this manner combined a ſufficient quantity of the two elaſtic fluids to obtain ſeveral drachms of water. Both theſe fluids were previouſly paſſed through a glaſs cylinder, filled with very dry cauſtic fixed alkali, in order to deprive them of the portion of water they might contain. The water obtained by the combuſtion, agreed perfectly in weight with the elaſtic fluids made uſe of; whence he concluded, that water is compoſed of ſix parts by weight of oxygen, and one of hydrogen gas, for it is eaſy to conceive, from all that we have already ſhown, that the caloric and the light are diſengaged from vital air and hydrogen gas during their combuſtion: it is to this diſengagement that we muſt attribute the weight of the water, compared with that of the oxygen and hydrogen gas; this fluid is ſpecifically heavier than hydrogen gas, as 11050 to 1, ſuppoſing that of the gas to be as 13 to 1, compared with common air; the ratio will be much greater if we aſſume the levity of the hydrogen gas as 16, which appears to be the caſe when it is perfectly pure. The water obtained in this experiment was found to contain a few grains of nitric acid. To account for the formation of this acid, it muſt be recollected, that Mr. Cavendiſh produced it, by combining, with the aſſiſtance of the electric ſpark, ſeven parts of vital air, and three of atmoſpheric azotic gas. Now, the vital air uſed by Lavoiſier, in his experiment, having been obtained from red precipitate, or a mercurial oxyd by nitric acid, the nitric acid, uſed in making that ſubſtance, might afford a ſmall quantity of the azot, which enters into its compoſition. This portion of acid, therefore, does not affect the reſult, nor the aſſertions of Lavoiſier concerning the production of water. If we compare this capital experiment, with that in which the ſame chemiſt decompoſed water, by cauſing it to fall on red hot iron, zinc, and charcoal, as well as on boiling oils, and in which he obtained hydrogen gas, in proportion to the combuſtion which took place in theſe different bodies, we ſhall be convinced, that this theory of the nature of water is built on as firm a foundation as any that has been propoſed reſpecting chemical facts. The proportion of the component parts of water, according to the moſt accurate experiments, is 85 parts of oxygen, and 15 of hydrogen, both by weight.

The nature of hydrogen gas remains then to be determined. Is it a ſimple ſubſtance, always identical? And may we conſider it as the phlogiſton of Stahl, according to the opinion of many Engliſh chemiſts, eſpecially Mr. Kirwan?

With reſpect to the firſt queſtion, chemiſts are at preſent nearly agreed concerning the identity of inflammable gas, obtained from very different ſubſtances, which appear to poſſeſs various properties.

There are indeed ſome who ſtill are of opinion, that ſeveral ſpecies really exiſt; ſuch, according to them, are the hydrogen gas obtained from iron and zinc by water, which burns with a red flame, and detonates with vital air; that which Mr. Delaſſone obtained from Pruſſian blue, and from the reduction of flowers of zinc by charcoal, which burns without detonating with air; the inflammable gas of marſhes, which burns with a blue flame, and does not detonate; and likewiſe that obtained from the diſtillation of organic matters, which reſembles the gas of marſhes. But an accurate analyſis has ſhown, that theſe two laſt are compounds of pure detonating hydrogen gas, with the azotic gas, or carbonic acid, in different proportions; and we were inclined to think, with the illuſtrious Macquer, in 1782, that there is only one ſubſtance of this kind capable of various modifications by its combinations with different matters. The labours of a great number of celebrated philoſophers, and in particular of Meſſrs. Cavendiſh, Prieſtley, Watt, Kirwan, Lavoiſier, Monge, Berthollet, Morveau, &c. have confirmed this opinion. The mixtures of the foreign gaſes before pointed out, the diſſolution of charcoal, of ſulphur, and of phoſphorus in hydrogenous gas, whoſe ſpecific gravity they augment while they diminiſh its combuſtibility, announce that the apparent differences of inflammable gaſes are owing to theſe mixtures or combinations. I think, therefore, that it may at preſent be conſidered as demonſtrated, that there is but one ſingle ſpecies of inflammable gas always ariſing from the decompoſition of water, forming it again by its union with vital air; and, in a word, that there exiſts in this genus hydrogenous gas only, which exhibits more or leſs inflammability, and various colours in its combuſtion, accordingly as it is mixed or combined with other different ſubſtances.

As to the ſecond queſtion, though the opinion of Bergman and the Engliſh chemiſts, who conſider hydrogen gas as the phlogiſton of Stahl, appears to agree with a certain number of facts, yet there is a greater number which prevent our adopting it. It appears, in fact, that inflammable gas is not always produced by bodies in which Stahl admitted the preſence of his phlogiſton, but that water almoſt always contributes to its formation. Mr. Kirwan, who has been employed for ſome years in the examination of this important queſtion, has not yet, that we know, diſcovered any fact which poſitively decides it. We ſhall take care to explain, in ſeveral other articles of this work, our opinion of the hydrogen gas, which this celebrated chemiſt has obtained from an amalgam of zinc, as well as ſome other analogous experiment, which ſeveral philoſophers have oppoſed to our doctrine. We ſhall not here enter into any detail of the objections which may be made, becauſe they might not be underſtood by ſuch as have only read the preceding part of this work, but ſhall reſerve our objections till we come to treat of metallic ſubſtances, phoſphorus, &c. However this may be, we ſhall here admit that it would be poſſible to explain the phenomena of chemiſtry, by admitting hydrogen for phlogiſton; but we muſt at the ſame time obſerve, that this theory of phlogiſton requires forced ſuppoſitions, and that it is very far from appearing as ſimple, as ſatisfactory, as that which we have adopted as the immediate reſult of the facts *.

No chemiſt has yet ſucceeded in ſeparating the principles of hydrogen gas, and conſequently it is a ſimple ſubſtance, in the preſent ſtate of our knowledge. Its baſe or hydrogen combines with that of pure air or oxygen, and forms water by this combination. We take no notice of the theories of thoſe who affirm, that hydrogen gas is a compound of air and the matter of fire, or that it is a modification of light, fire, electricity, &c.; for theſe aſſertions are all too vague, and bear too great a reſemblance to the inaccurate and uncertain language of the infancy of natural philoſophy, and are beſides too far removed from experiment and proof to merit diſcuſſion. Dr. Crawford has ſhown, according to Mr. Kirwan, that hydrogen gas contains more light and caloric than vital air, and that the proportion of light and of caloric in theſe gaſes is as 24 to 1. It would be of conſequence to determine how much of theſe principles the hydrogen loſes by entering into liquid or ſolid combinations. It cannot, however, be doubted, but that hydrogen gas contains much ſpecific heat, or caloric, perhaps the matter of light; and that the caloric is ſeparated from this gas, whenever it loſes its elaſtic ſtate, and paſſes into liquid combinations.

Hydrogen gas does not unite with water, but may be preſerved a long time over that fluid without alteration; though at laſt it ceaſes to be inflammable. Dr. Prieſtley has not de-

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* Conſult the tranſlation of Mr. Kirwan's work, and the notes we have added. *Note of the Author.*

termined what kind of change is produced, either in the inflammable gas or in the water; but it is probable, that this experiment, carefully made, would tend greatly to explain the nature of that combuſtible body.

Hydrogen gas does not appear to act on earths, nor on the three ſalino-terreſtrial ſubſtances; excepting, however, that it deſtroys the white colour of barytes, and renders it dark; which circumſtance has cauſed it to be conſidered as the calx or oxyd of a peculiar metal ſtill unknown.

The change which alkalis and acids might cauſe in this ſubſtance, and themſelves be ſubjected to by it, are not known. It is probable that it would decompoſe certain acids, eſpecially the ſulphuric and the oxygenated muriatic acids, by ſeizing their oxyen, and forming water: as to the ſulphuric acid, it may be ſuſpected, that it would experience this decompoſition, becauſe the baſe of vital air has a ſtronger affinity with hydrogen than with ſulphur; the latter not decompoſing water, as we ſhall hereafter ſee. The oxygenated muriatic acid has ſo large a quantity of ſuperabundant oxygen, which adheres ſo weakly, that it may be preſumed it would unite with the hydrogen gas, and form water.

Hydrogen gas does not appear to act on neutral ſalts; its action on ſaline ſubſtances in general has been little attended to. It is become a ſubſtance of greater importance, in the eyes of the ſcientific world, ſince it has been applied to the filling of aeroſtatic machines, diſcovered by Meſſrs. Montgolfier. Its ſpecific levity, which is thirteen times more conſiderable than that of common air, is the cauſe of the aſcenſion of theſe machines. It is more than probable, that this fluid has a conſiderable ſhare in the production of meteors; that it exiſts in large quantities in the atmoſphere, where, being ſet on fire by the electric ſpark, it forms water. Perhaps it may be carried by the winds, like a kind of natural aeroſtat.

Attempts have been made to ſubſtitute this fluid, inſtead of other combuſtible matters, for the ordinary purpoſes of life; to give light and heat, to charge fire-arms, &c. Volta has conſidered it in this laſt point of view, and has propoſed ſeveral methods of applying it. Neret, in the *Journal de Phyſique* for January 1777, has given a deſcription of a chafing-diſh heated by inflammable air. Meſſrs. Furſtenberger of Baſil; Brander, mechanic at Augſburg; Ehrmann, lecturer in Natural Philoſophy at Straſburg; have deſcribed lamps which may be lighted in the night by the electrical ſpark. Laſtly, Very pretty artificial fires are made, with glaſs tubes, bent in different directions, and pierced with a great number of ſmall apertures. The inflammable gas is introduced into theſe tubes, from a bladder filled with that fluid, and fitted with a copper cock. When the bladder is preſſed, the inflammable air being made to paſs into the tube, iſſues out of all the ſmall apertures, and is ſet on fire by a lighted taper.

CHAPTER IV.

GENUS III. SULPHUR.

SULPHUR is a combuſtible, dry, very brittle body, of a lemon yellow, which has no ſmell, unleſs heated, and whoſe taſte is very weak, though ſufficiently perceptible. It becomes electric by friction; if a piece of a conſiderable ſize be expoſed to a ſudden, though gentle heat, as for example, by holding it in the hand, it breaks to pieces, with a crackling noiſe. Sulphur is found naturally in great quantities, ſometimes pure, and ſometimes in a ſtate of combination. We ſhall in this place ſpeak only of the firſt: the following are the varieties of form in which it is found pure.

Varieties.

1. Tranſparent ſulphur, cryſtallized in octahedrons, whoſe two pyramids are truncated: it is depoſited by water, moſt commonly upon the ſurface of calcareous ſpar. Such is that of Cadiz.
2. Tranſparent ſulphur in irregular pieces; from Switzerland.
3. Whitiſh pulverulent ſulphur, depoſited in ſiliceous geodes: flints filled with ſulphur are found in Franche Comté, &c.
4. Pulverulent ſulphur, depoſited at the ſurface of mineral

waters; ſuch as thoſe of Aix la Chapelle, of Enghien near Paris, &c.

5. Cryſtalline ſulphur, ſublimed; it is tranſparent, and found in the neighbourhood of volcanos.
6. Pulverulent ſulphur, ſublimed by volcanic fires, without any regular form, and often interpoſed between ſoft ſtones, as is obſerved at Solfatara, near Naples.
7. Stalactites of ſulphur, formed by volcanic fires.

Beſides theſe ſeven varieties of pure mineral ſulphur, this combuſtible ſubſtance is found combined with different matters. It is uſually combined with metals, which it converts into *pyrites*, or metallic ſulphures and ores. It is ſometimes united to calcareous earth, in the form of a ſulphuric or an earthy liver of ſulphur. The hepatic calcareous ſtones, the fetid ſpar, and ſwine-ſtone, appear to be of this nature.

Late diſcoveries have added to the foregoing varieties. Sulphur ſeems to be continually formed in vegetable and animal matters which begin to putrify. Though theſe ſpecies of ſulphur do not appear eſſentially to belong to the mineral kingdom, yet we think it proper to join them with the preceding varieties, to render its natural hiſtory more complete.

Varieties.

8. Cryſtallized ſulphur, formed by the ſlow decompoſition of accumulated animal matters, ſuch as that which has been found in the ancient lay-ſtall *, near the gate of St. Antoine.
9. Pulverulent ſulphur, formed by the vapours diſengaged by animal ſubſtances in a ſtate of putrifaction. It is collected on the walls of ſtables, privies, &c.
10. Sulphur obtained from many vegetables, eſpecially the root of the baſtard rhubarb (Lapathum), the ſpirit of cochlearia, &c. This diſcovery, as well as the following, was made by Deyeux, member of the college of pharmacy, and lecturer in chemiſtry.
11. Sulphur, obtained in the analyſis of animal matters, particularly white of egg, by Deyeux.

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* A lay-ſtall (voierie) is a place appropriated, by the chief of a lordſhip, for the reception of mud, and other filth.

12. Sulphur obtained from horſe-dung. This combuſtible body has been found at the inſtant of its being emitted. It is probable, that ſubſequent inquiries will diſcover this body in a great number of animal ſubſtances.

None of theſe ſulphurs are uſed in the arts. The ſulphur of commerce is extracted, by diſtillation, from metallic ſubſtances, called pyrites. In Saxony, and in Bohemia, this mineral is put into earthen tubes, placed on a long furnace; the ends of the tubes, which iſſue out of the furnace, are received in ſquare iron veſſels, containing water; the ſulphur is collected in theſe receivers, but is very impure. In order to purify it, it is melted in an iron ladle; the earthy and metallic parts ſubſide to the bottom. It is then poured into a copper boiler, where it makes another depoſit of the foreign matters which contaminated it. After having been kept a certain time in fuſion, it is poured into cylindrical wooden moulds, which give it the form it uſually has in commerce; that which is precipitated to the bottom of the boiler during the fuſion, is grey, and impure: it is very improperly called *ſulphur vivum*. In other countries, as at Rammelſberg, the ſulphur is extracted from pyrites, in a more ſimple manner. The ſulphur, which is found melted among the maſſes of pyrites, roaſted in the open air, is taken away with ladles, and purified by a ſubſequent fuſion.

Sulphur is not altered by the contact of light; heated in cloſe veſſels, it becomes ſoft, melts, and in cooling often aſſumes a red, brown, and greeniſh colour, and needled form. To ſucceed in this cryſtallization, it muſt, according to the proceſs of Rouelle, be ſuffered to congeal at its ſurface; and the fluid portion, which is underneath the cruſt, muſt be poured off. The under ſurface of the congealed part preſents needles of ſulphur, croſſing each other in different directions.

If ſulphur be gently heated when in fuſion, it is volatilized in ſmall pulverulent parcels, of a bright lemon yellow, called *flowers of ſulphur*. As the part which riſes conſiſts of the pureſt ſulphur, this is the beſt proceſs for obtaining it free from foreign matters. For this purpoſe, common ſulphur, in powder, is put into an earthen cucurbit, to which pots are adapted, which mutually cover each other, and are called *aludels*. The upper is terminated by a reverſed funnel, whoſe opening forms a ſlight communication with the air; the cucurbit is heated till the ſulphur melts, at which time it ſublimes, and adheres to the ſides of the aludels.

Flowers of ſulphur, prepared in the large way, often contain a ſmall quantity of ſulphuric acid, formed by the combuſtion of the ſulphur, which is effected by the air contained in the veſſels: it is thoroughly purified by waſhing: ſulphur ought to be prepared in this way for medical, and the nicer chemical purpoſes.

Sulphur, heated with contact of air, takes fire ſoon after it is melted, and burns with a blue flame, if the heat to which it has been ſubjected be not conſiderable; or with a white, brilliant flame, when the heat is ſtronger. In the firſt of theſe combuſtions, it emits a ſuffocating ſmell; and if the vapour which exhales be collected, it is found to conſiſt of a very ſtrong ſulphureous acid. In the rapid combuſtion it has no ſmell, and its reſidue is not ſulphureous acid, but ſulphuric acid.

Stahl, who imagined that ſulphur was a compound of that acid and phlogiſton, ſuppoſed, that during combuſtion it loſt its inflammable principle, and conſequently became reduced to the ſtate of acidity. The collection of proofs, brought by him in ſupport of this opinion, was well calculated to cauſe it to be adopted by all ſucceeding chemiſts. However, ſince experiments have been made with a view to aſcertain the influence of air in combuſtion, to which Stahl does not appear to have attended, ſome chemiſts, ſtruck with the difficulty hitherto experienced in the attempt to exhibit plogiſton alone, and the facility with which all the objections to this doctrine are anſwered by the late diſcoveries reſpecting air, have adopted an opinion entirely oppoſite to that of Stahl, concerning ſulphur and its combuſtion.

The facts on which the new opinion is founded are theſe: Hales obſerved that ſulphur abſorbs a great quantity of air when burned. Lavoiſier has demonſtrated that ſulphur in this reſpect reſembles all other combuſtible bodies: 1. That it cannot burn without acceſs of air. 2. That it abſorbs the pureſt portion of this fluid during its combuſtion. 3. That the reſidue of the atmoſpheric air is incapable of maintaining a new combuſtion. 4. That the ſulphuric acid produced exceeds the quantity of ſulphur from which it was produced, by the weight the air has loſt. 5. That conſequently ſulphur combines with the baſe of pure air, or oxygen, to form ſulphuric acid. This acid is therefore a compound of oxygen and ſulphur; and the latter, inſtead of being a compound, is one of the principles of ſulphuric acid, which requires only to be united with the baſe of air or oxygen, to form that acid, a proceſs that takes place during combuſtion. Heat is neceſſary, becauſe it divides and deſtroys the aggregation, and favours its combination with oxygen. When it is once burned or combined with the latter principle, it is no longer capable of being inflamed, but enters into the claſs of incombuſtible bodies.

According to the manner in which it is burned, it abſorbs different quantities of oxygen, and becomes more or leſs acid. Such is the theory of the difference which exiſts between the ſlow and rapid combuſtions of ſulphur, and the ſulphureous and ſulphuric acids reſulting from each. Stahl ſuppoſed, that when ſulphur is ſlowly burned it does not loſe all its phlogiſton, and that the ſulphuric acid retaining a portion of that principle, preſerves its ſmell and volatility: but it is now proved by experiment, that when ſulphur burns ſlowly, it does not abſorb as much of the oxygen as it is capable of uniting with; whereas in the rapid combuſtion, it becomes ſaturated with that principle, and conſtitutes ſulphuric acid. The ſulphureous acid combined with alkaline matters becomes gradually converted into ſulphuric acid, by abſorbing the baſe of vital atmoſpheric air.

It will be eaſy to form a clear notion, according to this theory, of what happens when ſulphur is formed with the ſulphuric acid and certain combuſtible matters, as we have obſerved with reſpect to the ſulphats of potaſh, of ſoda, the ammoniacal, calcareous, magneſian, argillaceous, and barytic ſulphats heated with charcoal. The charcoal ſeizes the oxygen contained in the ſulphuric acid, and conſequently leaves the ſulphur, which is its other principle. Whenever, therefore, the ſulphuric acid is changed into ſulphur by any combuſtible body, the latter is always reduced to the ſtate of a body which has ſuffered combuſtion, as we ſhall obſerve in the hiſtory of many metallic ſubſtances. For this reaſon likewiſe it is, that a large quantity of carbonic acid is obtained during the artificial production of ſulphur, namely, by the tranſition of the oxygen from the ſulphuric acid to the carbonaceous matter. It muſt be recollected, that the preſence of the baſe of pure air or oxygen is eaſily demonſtrated in the ſulphuric acid.

Sulphur is not at all changeable by expoſure to air, nor ſoluble in water. If it be held a certain time in fuſion, and poured into that fluid, it becomes red, and preſerves a certain degree of ſoftneſs, ſo that it may be kneaded; but it loſes theſe properties in a few days. Water, let fall drop by drop into burning ſulphur, is not decompoſed, and does not maintain the combuſtion, which proves that the baſe of vital air, or oxygen, has a ſtronger affinity with hydrogen than with ſulphur. This aſſertion may be confirmed by the action of hydrogen gas on the ſulphuric acid, which it appears to deprive of the oxygen.

Sulphur has no action on ſiliceous earth, and does not unite with alumine, without difficulty. The latter, however, when exceedingly divided, appears to reduce ſulphur to the hepatic ſtate, or that of a fœtid ſulphure, as is ſeen in the preparation of pyrophorus.

The general name of *alkaline ſulphure*, *hepar*, or *liver of ſulphur*, has been given to a compound formed of ſulphur, with ſome alkaline ſubſtance. This compound, conſidered in general, is of a brown colour, reſembling that of the liver of animals; decompoſable by vital air; ſoluble in water, in which ſtate of ſolution it emits a fœtid ſmell; precipitable in part by acids, which diſengage a peculiar gas, called *hepatic gas*, which, from its compoſition, we ſhall term ſulphurated hydrogen gas. There are ſix kinds of alkaline ſulphures produced by barytes, magneſia, lime, and the three alkalis. The properties of each require to be particularly examined.

Pure barytes does not appear to act ſtrongly on ſulphur; when theſe are boiled together with water, the liquid becomes in a ſmall degree ſulphurated or hepatic; but it combines much more intimately in the dry way. When a mixture of eight parts of ſulphat of barytes in powder with one part of charcoal, is ſtrongly heated in a crucible, a coherent maſs is obtained without fuſion, which readily diſſolves in hot water, and has the ſmell and every other character of a hepar. The ſolution is of a golden or orange colour. I have diſcovered that it cryſtallizes by cooling; it is then of a yellowiſh white. Expoſure to air decompoſes it, when it attracts moiſture, and becomes of deeper colour; ſulphur being precipitated, and ſulphat of barytes regenerated. This ſulphure gives out on the addition of any acid, an elaſtic fluid, known by the name of ſulphurated hydrogen gas, whoſe properties we ſhall hereafter examine. When the barytic ſulphure is precipitated by ſulphuric acid, ſulphur and ſulphat of barytes fall down; if nitric or muriatic acid be uſed, the barytic nitrat or muriat remains in ſolution, and the ſulphur is depoſited alone.

Sulphur combines with pure magneſia, by the aſſiſtance of heat. The ſalt, which we have called carbonat of magneſia, is commonly uſed for this purpoſe, becauſe more ſoluble in water. A pinch of magneſia, with a like maſs of the flowers of ſulphur, is put into a bottle with diſtilled water; this veſſel being perfectly filled, and well ſtopped, is expoſed to the heat of a water-bath for ſeveral hours. The water being then filtered, has a fœtid ſmell of rotten eggs; ſtrongly colours metallic ſolutions, and affords ſmall cryſtalline needles by ſpontaneous evaporation: in a word, it is a true magneſian ſulphure, the magneſia being precipitable by fixed alkali, which has a ſtronger affinity with the ſulphur. As to the latter combuſtible ſubſtance, its preſence is eaſily aſcertained by the addition of an acid, which ſeparates it under the form of a white powder. Such was the kind of liver of ſulphur which Le Roi, phyſician at Montpellier, diſſolved in pure water, to imitate the ſulphureous mineral waters; but it is now known, that moſt of thoſe waters do not contain a true ſulphure, but are mineralized ſimply by impregnation with ſulphurated hydrogen gas.

Lime unites much more readily with ſulphur than the two ſalino-terreſtrial ſubſtances before mentioned. If water be poured by a little at a time on a mixture of quick-lime and flowers of ſulphur, the heat produced by the action of the water on the lime is ſufficient to promote the combination between it and the ſulphur. If more water be added, it becomes reddiſh, and emits a fœtid odour, being in fact a ſolution of ſulphur combined with lime. This calcareous ſulphure is not well prepared, but by the humid way, and it is often neceſſary to aſſiſt the combination by the the application of a gentle heat, when the lime is not freſh. This compound is of a red colour; and the more cauſtic the lime, the deeper the red. When it is highly ſaturated, I have obſerved that it depoſits, by cooling, a layer of ſmall needled cryſtals of an orange yellow, diſpoſed in tufts, which appeared to me to conſiſt of flattened tetrahedral priſms, terminated by dihedral ſummits. Theſe cryſtals gradually loſe their colour by expoſure to air, and become white and opaque, without any alteration in their form, Calcareous ſulphure moiſtened with a ſmall quantity of water, and diſtilled in the pneumato-chemical apparatus, is partly decompoſed, and affords a large quantity of ſulphurated hydrogen gas: if it be evaporated to dryneſs, and calcined in an open crucible till it emits no more fumes, the reſidue conſiſts of calcareous ſulphat, formed by the lime and the ſulphuric acid, produced by the ſlow combuſtion of the ſulphur. Calcareous ſulphure is quickly changed by expoſure to air, loſing its ſmell and colour, in proportion as its gas is diſſipated. When diſſolved in a large quantity of water, the ſame alteration takes place, eſpecially when it is agitated, as Monnet obſerves, in his Treatiſe on Mineral Waters. Sulphat of lime remains after thoſe changes. When preſerved in bottles, not quite full, it depoſits a black incruſtation on the glaſs, pellicles being at the ſame time formed, which fall to the bottom of the liquor. If the veſſel which contains it be well cloſed, it may be kept a long time without change, as I have often obſerved in my laboratory. I have ſeen a preparation of this nature which has been made fifteen years; it ſtill preſerves much of its colour and ſmell, and affords an abundant precipitation by acids. Calcareous ſulphure is decompoſed by pure fixed alkalis, which have a ſtronger affinity than lime to the ſulphur. Acids precipitate the ſulphur in the form of a very ſubtle white powder, which has been called *magiſtery of ſulphur*. The carbonic acid effects this ſeparation as well as the others; but the action of neutral ſalts on calcareous ſulphure is not known.

The two pure or cauſtic fixed alkalis, have a very ſtrong action on ſulphur; they form the true ſulphures, which are leſs decompoſable, and more permanent, than the other. I have diſcovered, that the dry fixed cauſtic alkalis act on ſulphur when in the cold. The pure fixed alkali and the ſulphur in powder muſt be triturated in a mortar; the moiſture of the air attracted by the alkali favours the re-action of the ſalt on the ſulphur. The mixture becomes ſoft, aſſumes an yellow colour, emits a fœtid ſmell, and is converted into a ſulphure; but when this ſulphure is diſſolved in water, the ſolution is of a pale yellow colour, and is found to contain a leſs quantity of ſulphur than the ſame ſulphure prepared by heat. The alkaline ſulphure is prepared in laboratories in two methods, by the dry or by the moiſt way; the firſt proceſs is performed by melting equal parts of pure and ſolid potaſh or ſoda, and flowers of ſulphur in a crucible: as ſoon as the mixture is entirely melted, it is to be poured out on a marble ſlab, and appears when cool to be of a red brown colour, reſembling that of the liver of animals. Gengembre, who has communicated to the Academy a ſeries of very valuable experiments concerning ſulphurated hydrogen gas, makes an important obſervation on the alkaline ſulphure prepared by the dry way; namely, that this compound is not fœtid, and does not emit ſulphurated hydrogen gas, while it is dry; its ſmell not becoming perceptible till it has attracted moiſture from the atmoſphere, or is diſſolved in water: a fact which proves that water diſengages the fœtid gas, as we ſhall more fully explain. The two pure and cauſtic fixed alkalis act abſolutely in the ſame manner on ſulphur, and are equally capable of diſſolving it by the dry way. Theſe combinations of cauſtic alkalis with ſulphur have hitherto been little attended to; alkaline ſulphure having almoſt always been made with fixed alkalis, ſaturated with the carbonic acid. Yet there are remarkable differences between theſe two kinds of ſulphures; thoſe made with the effervеſcent fixed alkalis require a longer time for their preparation, becauſe theſe ſalts are much leſs active. But the moſt important difference we have had occaſion to obſerve between the ſulphures made with cauſtic or mild alkalis in the dry way, is the comparative ſtate of their ſaturation. In fact, the firſt are brown, and more fœtid when diſſolved, and the gas they afford is much more inflammable than that of the ſecond. Theſe laſt are of a paler colour, often of a greeniſh grey; their ſmell is weaker, and their compoſition leſs durable. The carbonats of fixed alkalis appear to preſerve their acid in their union with ſulphur, the gas of theſe ſulphures not being inflammable till it has been deprived of its carbonic acid, by waſhing it in lime-water. The cauſe of the differences between ſulphures made with cauſtic alkalis, and thoſe made with mild alkalis, conſiſts therefore in the preſence of the acid in the latter, which diminiſhes the effect of the alkali.

Solid alkaline ſulphure, made with either of the cauſtic alkalis, is very fuſible, and, like calcareous ſulphure, is decompoſed by expoſing it to the air when heated in cloſe veſſels; after having been moiſtened with a ſmall quantity of water, it gives out much ſulphurated hydrogen gas. It is capable of aſſuming a cryſtalline form when it becomes ſolid after fuſion; but this form has not yet been well deſcribed. While hot and dry it has a brown colour; in proportion as it cools and attracts the humidity of the air, it loſes its colour, and becomes paler. The contact of the air ſoon gives it a greeniſh yellow colour; after which it is rendered liquid by the moiſture it attracts, and is ſlowly decompoſed, ſo as to become converted at the end of a certain time into ſulphat of potaſh or of ſoda. It diſſolves readily in water, immediately aſſuming a peculiar fœtid ſmell; the hepatic gas being formed by the re-action of the water: this ſolution is of a deep red alkaline colour, if the ſulphure has been recently prepared, but otherwiſe a green. The alkaline ſulphure, prepared in the humid way, by heating a ſolution of either of the cauſtic fixed alkalis in water, with half their weight of powdered ſulphur, exhibit the ſame properties as the ſolution here mentioned: we may therefore deſcribe both under the common name of *liquid alkaline ſulphure.*

The liquid alkaline ſulphure, when very ſtrong, depoſits irregular needle-formed cryſtals by cooling. It is decompoſable by the action of heat. When diſtilled in the pneumato-chemical apparatus, it affords ſulphurated hydrogen gas: expoſure to air likewiſe decompoſes it, ſo that it becomes turbid; pellicles are then formed, and ſulphur depoſited. Bergman and Scheele thought that this decompoſition is produced by the vital air of the atmoſphere; a ſmall quantity of liquid alkaline ſulphure being placed under a glaſs veſſel with vital air, the latter is entirely abſorbed, and the ſulphure decompoſed. Scheele has even propoſed the application of this fact to eudiometrical purpoſes; and it is in fact one of the beſt methods of aſcertaining the purity of the air.

Earths, and ſalino-terreſtrial ſubſtances, have no action on alkaline liquid ſulphure when very pure; but if it has been prepared with the carbonats of potaſh or ſoda, it becomes turbid by the addition of lime-water. Acids decompoſe it, by uniting with the alkali, and precipitating the ſulphur in the form of a very fine white powder. Nitric acid, poured on ſolid alkaline ſulphure in fuſion, produces a detonation, according to Prouſt. The oxygenated muriatic acid, poured in a large quantity upon a ſolution of alkaline ſulphure, precipitates little or nothing, becauſe it re-diſſolves the ſulphur by virtue of its oxygen, which, being nearly at liberty, unites quickly to this combuſtible body, and converts it into the ſulphuric acid. This fact may be ſhown, in the moſt convincing manner, from an experiment I have made, of pouring into it a mixture of barytic muriat, which produces an abundant precipitate of the ſulphat of barytes.

To obtain this gas, an acid muſt be poured on pulverized ſolid alkaline ſulphure, a ſtrong effervefcence is produced, which does not take place in the ſame manner, if the acid be poured into a ſolution of this compound. This phenomenon, which has ſcarcely been attended to by chemiſts, depends on two circumſtances: 1. Solid alkaline ſulphure, according to the obſervation of Gengembre, does not contain hepatic gas, or ſulphurated hydrogen ready formed; but when an acid is poured on it, the water, which holds this laſt ſalt in ſolution, contributes to its formation. As the quantity inſtantly produced is very conſiderable, and the gas does not find a body which may retain it in ſolution, it eſcapes, occaſioning a ſtrong effervefcence; ſo that when the experiment is made in a bottle, to which a tube is adapted, the gas may be eaſily collected over mercury. 2. The ſolution of alkaline ſulphure contains a conſiderable quantity of gas ready formed; though a part of the gas was diſengaged during the act of its ſolution; and when an acid is added, the portion of gas which is diſengaged becomes diſſolved in the water, ſo as not to produce a ſenſible effervеſcence; or at leaſt the effervеſcence is very inconſiderable, and the quantity of gas collected is but ſmall.

Sulphurated hydrogen gas, which is the ſame in all earthy or alkaline ſulphures, and is their diſtinguiſhing characteriſtic, has been long known by its fœtid ſmell, and by its action on metals and metallic oxyds, particularly thoſe of lead and biſmuth, which it renders entirely black. Its ſmell is inſupportable; it ſuddenly deſtroys animal life, renders ſyrup of violets green, and burns with a very light blue flame: if it be ſet on fire in a large and very clean glaſs veſſel, it depoſits on the ſurface of the glaſs a yellowiſh pellicle, which is found to be ſulphur. This gas is decompoſed by vital air, and depoſits its ſulphur whenever it comes in contact with atmoſpheric air; it is from this cauſe that ſulphur is found floating in the form of flowers on the ſulphureous waters, which it mineralizes, though they do not contain true alkaline ſulphur. The ſulphur depoſited from the waters of Aix-la-Chapelle, Enghien, &c. has the ſame origin. From this cauſe likewiſe, ſulphureous depoſitions are made on that part of bottles which contain ſolutions of alkaline ſulphures. Bergman attributes this decompoſition to the ſtrong affinity of pure air with phlogiſton. He conſiders hepatic gas as a combination of ſulphur, phlogiſton, and the matter of heat; when one of theſe principles is ſeparated, the other two become diſunited. Mr. Gengembre, ſtruck with the obſervation, that ſulphures do not give out ſulphurated hydrogen gas when water is not preſent, concluded that this fluid, by its decompoſition, contributes to the formation of the gas; that its vital air unites with a part of the ſulphur, and its hydrogen gas diſſolves a ſmall portion, which ſolution conſtitutes ſulphurated hydrogen gas. He imitated the formation of this gas, by melting ſulphur over mercury in a jar containing hydrogen gas, by the ſolar focus of a lens of nine inches in diameter: part of the ſulphur became diſſolved in the gas, which aſſumed all the characters of hepatic gas; but as the ſulphur alone cannot decompoſe water, and as oxygen has a ſtronger affinity with hydrogen than with that combuſtible ſubſtance, Gengembre thinks that the alkali favours the decompoſition of water by ſulphur, by reaſon of its tendency to unite with the product of the combination of ſulphur with oxygen; that is to ſay, with ſulphuric acid. To ſupport this theory, Gengembre obſerves, that the quantity of ſulphurated hydrogen gas diſengaged from alkaline ſulphure, is in proportion to the force with which the acid made uſe of retains its oxygen; becauſe the water is in that caſe decompoſed, rather than the acid. Such, according to him, is the reaſon why the muriatic acid affords one half more of this gas than the nitric, as obſerved by Scheele and Sennebier. Laſtly, The proceſs of Scheele for obtaining a large quantity of ſulphuratated hydrogen gas, which conſiſts in diſſolving an artificial pyrites, compoſed of three parts of iron, and one of ſulphur, in diluted ſulphuric acid, tends greatly to eſtabliſh this opinion. It therefore appears, that the vital air decompoſes ſulphurated hydrogen gas, by uniting and forming water with the hydrogen, while the ſulphur precipitates.

Water diſſolves ſulphurated hydrogen gas with conſiderable facility. This ſolution is a perfect imitation of ſulphureous mineral waters.

Earths and alkaline ſubſtances do not appear to act on this gas.

The ſulphuric acid does not decompoſe this gas, but the ſulphureous acid ſeparates its ſulphur, becauſe its oxygen, being partly at liberty, ſeizes more readily upon the hydrogen of the gas.

The nitrous acid, in which the oxygenous principle is very weakly retained, quickly decompoſes ſulphurated hydrogen gas, and precipitates the ſulphur. This acid is advantageouſly uſed as a teſt of the preſence of ſulphur in ſulphureous waters[b].

Alkaline ſulphure decompoſes earthy neutral ſalts, as well as metallic ſolutions, as we ſhall hereafter ſee.

The liquid ammoniac has ſcarcely any action on concrete ſulphur; though Boerhaave affirms that this fluid, by long ſtanding on flowers of ſulphur, afforded him a gold coloured tincture. To combine theſe bodies, they muſt be preſented to each other in a ſtate of vapour. With this intention, a mixture of equal parts of quick-lime and muriat of ammoniac, with half a part of flowers of ſulphur, are diſtilled together. In this diſtillation, which muſt be carefully conducted, a reddiſh yellow liquor is obtained of a penetrating ammoniacal ſmell, and ſomewhat hepatic. In a word, a true ammoniacal ſulphure, which has the property of emitting whitiſh fumes, when in contact with air, whence it is called the *fuming liquor of Boyle.* This ammoniacal ſulphure is decompoſed by heat. At the end of a certain time, a large quantity of ſmall rainbow-coloured needles, one or two lines in length, are formed, which appear to be the concrete and cryſtallized ammoniacal ſulphure. A light, blackiſh, and frequently golden-coloured cruſt, is depoſited on the ſides of the bottles. Lime and fixed alkalis decompoſe the fuming liquor; acids likewiſe precipitate the ſulphur with great facility, and diſengage a very inflammable ſulphurated hydrogen gas. The ammoniacal ſalts, produced in theſe decompoſitions, differ according to the nature of the acid made uſe of. A miſtake made in one of my lectures, produced an accidental diſcovery, which deſerves to be mentioned. Being deſirous of precipitating the fuming liquor of Boyle, I took a bottle, placed on my table, with the title of *ſpirit of vitriol;* it contained only a very ſmall quantity of the fluid, which prevented me from perceiving that it was very concentrated ſulphuric acid. I poured a few drops into the ammoniacal ſulphure; a rapid inteſtine motion was inſtantly excited, a very denſe white cloud iſſued out of the veſſel in which the mixture was made, and a noiſe, reſembling that of a large fuſee, immediately followed. The liquor flew out of the glaſs, the veſſel became very hot, and broke into a great number of pieces; nothing remaining but a yellowiſh thick magma, reſembling ſulphur, on ſome of the fragments. I have carefully repeated this experiment a great number of times, conſtantly with the ſame reſult. The whole mixture is thrown out, after a violent commotion; but the different phenomena ſucceed each other with ſuch rapidity, that it is impoſſible to avoid confounding them together. The moſt fuming nitrous acid did not appear to produce the ſame effect on the ammoniacal ſulphure prepared ſome time before; the mixture is ſtrongly agitated; much heat and ebullition is produced; a white cloud of ammoniacal nitrat riſes, but no exploſion follows, as is produced by concentrated ſulphuric acid on the ſame *hepatic* liquor, though made a long time before. Prouſt affirms, that nitrous acid, poured on two drachms of the fuming liquor of Boyle, produces a report equally violent with that of the ſame quantity of fulminating powder. This phenomenon does not appear to take place, but with the ammoniacal ſulphure recently prepared.

Ammoniacal carbonat likewiſe unites with ſulphur. Whenever theſe two bodies meet in the vaporous form, they unite, and compoſe a concrete ammoniacal ſulphure. It may be obtained, by diſtilling a mixture of equal parts of carbonat of potaſh, of lime, and of ammoniacal muriat, with half a part of ſulphur. This ſulphure is of a red brown, and cryſtallized; it emits ſome white vapours when diſſolved; is decompoſed by heat; is changed, and loſes its colour, by expoſure to air; is decompoſed by acids, &c. The ſulphurated hydrogen gas which it affords contains carbonic acid. It muſt be obſerved, that this concrete ammoniacal ſulphure is merely ammoniacal carbonat, vitiated by a ſmall portion of the *fuming liquor of Boyle;* for it is impoſſible that the ammoniac ſhould hold ſulphur in ſolution, while it is combined with the carbonic acid, which has the property of precipitating the ſulphur of the ammoniacal ſulphure very readily.

Several acids act upon ſulphur. If ſulphuric acid be boiled on ſulphur, the acid aſſumes an amber colour, and a ſulphureous ſmell; the ſulphur melts, and floats like oil: in cooling, it forms concrete globules, of a green colour, which is deeper, in proportion to the time it has been expoſed to the action of the acid. The acid diſſolves a ſmall part of the ſulphur, which is precipitable by an alkali, as Baumé has ſhown. This experiment, and many others of the like nature, convinced Berthollet, that the ſulphureous acid conſiſts of the ſulphuric acid, which holds ſulphur in ſolution. And in fact, this opinion agrees with all the modern experiments, which ſhow the ſulphureous acid differs from the ſulphuric in no other reſpect, but in containing a greater proportion of ſulphur.

The ſmoking nitrous acid acts ſtrongly on ſulphur. Prouſt was the firſt who obſerved, that a detonation and inflammation are produced when red nitrous acid is poured on melted ſulphur. Chaptal has made a ſeries of experiments relative to this ſubject; he ſucceeded in diſſolving and converting ſulphur into ſulphuric acid, by diſtillation, with the addition of nitrous acid. Hence it appears oxygen has a ſtronger affinity with ſulphur than with azot or baſe of nitric acid.

The common muriatic acid produces no change in this combuſtible ſubſtance; but the oxygenated muriatic acid, is capable of acting more ſtrongly on it. It burns it even in the midſt of water, and converts it quickly into ſulphuric acid. The ſulphur is ſeen diſſolving in the water. Experiments have not, however, been ſufficiently varied, to render it neceſſary for us to dwell longer on this ſubject.

Sulphuric neutral ſalts have no action on ſulphur; nitric ſalts, on the contrary, cauſe it to burn with rapidity, even in cloſed veſſels. Nothing can be more ſimple than the theory of this important phenomenon. Nitre, decompoſed by heat, affords a very large quantity of vital air. Sulphur is a very combuſtible ſubſtance; that is to ſay, it has a ſtrong tendency to unite with oxygen: it therefore finds that, in the nitre which is neceſſary for its combuſtion, and does not therefore need the contact of atmoſpheric air for that purpoſe. The products are very different, according to the reſpective quantities of nitre and of ſulphur employed. If a mixture of eight parts of ſulphur, and one of nitre, be ſet on fire in a cloſe veſſel, the ſulphur burns with a very brilliant white flame, and becomes converted into ſulphuric acid. This method has been uſed in England, and in Holland, for more than twenty years, for preparing this acid, which was before obtained from *vitriol.* Very large glaſs veſſels, capable of holding about four or five hundred pints, having a large neck, were at firſt uſed in England. Theſe were placed beſide each other, on a bed of ſand, in two rows, at a ſufficient diſtance from each other to be conveniently come at. A few pounds of water were put into each of theſe veſſels. A ſtone-ware pot was introduced into the neck of each veſſel, on which a ladle of iron, previouſly made red hot, was placed. Into this laſt, by means of another ladle of tin-ware, a mixture of ſulphur and nitre, in due proportion, was put; the aperture of the glaſs veſſel being immediately cloſed with a ſtopper of wood. The heat of the iron ladle ſet theſe ſubſtances on fire; the ſulphur became burned by the oxygen of the nitre; and when the combuſtion was finiſhed, the veſſel was taken out, and the vapours ſuffered to condenſe. The ſame operation was made in each of the glaſs veſſels compoſing the two rows, ſo that the workman, after paſſing through the whole range, arrived at the firſt veſſel, at the time when the vapours were totally condenſed, and the veſſel conſequently in a ſtate to receive a new portion of the burning matter. When the water was ſufficiently charged with acid, it was taken out, and poured into glaſs retorts, and the acid concentrated, by diſtilling off the aqueous part, till a bottle, capable of holding an ounce of diſtilled water, would contain one ounce ſeven drachms and a half of the acid. Such was the method of preparing *oil of vitriol*, or concentrated ſulphuric acid in England, which was very expenſive, on account of the price and brittleneſs of the large glaſs veſſels. But ſulphur has been for ſome years burned for this purpoſe in iron grates, placed within large chambers, lined on all ſides with lead; the ſulphuric acid being conducted by gutters, as it is condenſed, into a receiver. It is afterwards concentrated by the action of fire. This proceſs is uſed in the manufactory of Javelle, near Paris, the eſtabliſhment of which cannot but be very uſeful to the arts. It is proper to obſerve, that the ſulphuric acid obtained by this proceſs, always contains a ſmall portion of ſulphur and ſulphat of potaſh, together with a little ſulphat of alumine and ſulphat of lead; but the quantity of theſe ſubſtances is ſo ſmall, as to have no ſenſible effects in moſt of the uſes to which this ſaline matter is applied. It is, beſides, very eaſy to purify it for the nicer purpoſes of chemiſtry, by diſtilling it to dryneſs.

If, inſtead of burning ſulphur with the addition of one-eighth part of nitre, the doſe of the latter be augmented, ſo as to be equal to that of the ſulphur, ſulphat of potaſh, formed by the combination of the ſulphuric acid with the fixed alkaline baſe of the nitre, will be obtained, inſtead of the diſengaged ſulphuric acid. The ſalt obtained in this method, is called the *polychreſt ſalt of Glaſer.* It is prepared, by throwing a mixture of equal parts of ſulphur and nitre, into a red hot crucible; the reſidue is diſſolved in water, evaporated to a pellicle, afterwards filtered, and affords, by cooling, true ſulphat of potaſh, which has been diſtinguiſhed by the name of its inventor, Glaſer; though it does not at all differ from common ſulphat of potaſh.

A mixture of ſulphur and nitre with charcoal, compoſes gunpowder, whoſe terrible effects ariſe from its great combuſtibility. It is formed, for the moſt part, of nitre, with a much ſmaller proportion of charcoal, and ſtill leſs of ſulphur. One hundred pounds of gunpowder of Eſſone, near Corbeil, contain ſeventy-five pounds of nitre, nine pounds and a half of ſulphur, and fifteen of charcoal. This mixture is triturated for ten or twelve hours, in wooden mortars, with peſtles of the ſame ſubſtance, a very ſmall quantity of water being added from time to time. When almoſt the whole of the fluid is evaporated, ſo that the powder will not ſoil an earthen plate, it is carried to be granulated. This is effected, by cauſing it to paſs through a number of ſieves of ſkin, which are moved backwards and forwards in a right line. The holes in theſe ſieves are of various ſizes, down to that of cannon powder. The duſt, or meal powder, is ſeparated from the grains by ſifting. The grains are then carried to the drying-houſe, which is a ſhed expoſed to the ſouth, with glaſs windows, ſo as to receive the rays of the ſun. Cannon powder receives no other preparation than we have here mentioned. Muſket powder is glazed, that it may not ſoil the hands. To perform this operation, a caſk, mounted on an axis, and turned by a water wheel, is half filled with powder. The motion of the caſk excites continual friction, by which the grains of the powder are worn ſmooth. The duſt is ſeparated from this glazed powder by a ſieve, and the grains are likewiſe ſeparated by another ſieve, into a finer and a coarſer ſort. Baumé, in conjunction with the Chevalier D'Arcy, has made a very numerous ſet of experiments on the method of preparing gunpowder, on the reſpective forces of this compound, made with different proportions of the ingredients, and on the analyſis of this ſubſtance. Out of the many valuable circumſtances of information derived from theſe experiments, we ſhall ſelect the moſt important, and ſuch as have an immediate reference to chemical theory. 1. Good powder cannot be made without ſulphur, as has been propoſed by ſeveral perſons; this ſubſtance being found greatly to increaſe its force. 2. Every kind of charcoal, whether light or heavy, except animal coal, is equally fit for making gunpowder. 3. Charcoal is one of the moſt uſeful ingredients, a mixture of ſulphur and nitre not producing an effect to be compared with that of gunpowder. 4. The goodneſs of gunpowder depends entirely on the accurate mixture and trituration, continued till the powder riſes in the form of duſt about the mortar. 5. Powder has a much greater effect when ſimply dried, than when grained The moiſture neceſſary to grain the powder, cauſes the nitre to ſeparate, by cryſtallization, from the other ſubſtances; ſo that it may be obſerved, by a magnifier, in the internal part of grains of powder, cut in two. 6. Glazed, or muſket powder, is leſs ſtrong than unglazed powder, becauſe the particles of the former are cloſer together, and conſequently leſs inflammable. As to the analyſis of gunpowder, Baumé performs it in a very ſimple manner: his proceſs conſiſts in waſhing the gunpowder, well pulverized, with diſtilled water, and evaporating the water, which of courſe affords the nitre in cryſtals; the reſidue contains the ſulphur and charcoal. Sublimation does not completely ſeparate the former, becauſe it appears to be partly more fixed by the charcoal. Baumé, to ſeparate them, burned the ſulphur by a heat not ſufficient to burn the charcoal. The latter, however, always retains a ſmall quantity of ſulphur, ſince, according to the obſervation of that chemiſt, it emits a ſulphureous ſmell till it is entirely reduced to aſhes. He eſtimates the ſulphur, retained by the charcoal, at one twenty-fourth of its weight. Gunpowder may likewiſe be deprived of its ſulphur, by expoſing it entire, and without previous waſhing, to the action of a gentle heat, as Mr. Robins, in his Treatiſe on Gunnery, written in the Engliſh language, has obſerved. The perſons who ſteal game have been long in the habit of deſulphurating gunpowder, by expoſing it in a tin diſh to the heat of a bed of aſhes. They are perſuaded, that the powder, in this ſtate, impells the ſhot to a much greater diſtance, and does not ſoil the piece ſo much.

Chemiſts and natural philoſophers have maintained various opinions reſpecting the violent effects of gunpowder; ſome have attributed them to water, reduced into vapour, and others to the ſudden dilation of air. Baumé ſuppoſed them to ariſe from a nitrous ſulphur, formed in the inſtant of combuſtion. For our part, we think this phenomenon may be very readily explained, by the application of the modern improvements in chemiſtry. To render our theory more perſpicuous, it muſt firſt be obſerved, that all the phenomena, which attend the inflammation of gunpowder, depend entirely on its great combuſtibility. But ſulphur and carbon minutely divided, are bodies highly inflammable. The intimate mixture, which has ſo great an influence on the force of gunpowder, as Baumé's valuable experiments have ſhown, is the only cauſe of its effects. The nitre is equally diſperſed among all the particles of very combuſtible matter : as its quantity is much the greateſt, each particle of ſulphur and charcoal is ſurrounded, and, as it were, covered with nitre. A much greater quantity of vital air, than is neceſſary for the complete combuſtion, will be produced ; it being well aſcertained, that nitre affords that fluid in great quantities, by the application of heat. The ſame thing happens in this combuſtion, as is obſerved, when a combuſtible body is plunged in a veſſel filled with vital air ; that is to ſay, it is burned with great vivacity, and in much leſs time than in the common atmoſpheric air. It follows, therefore, that the ſulphur and the charcoal muſt be burned in an inſtant, becauſe they are really plunged in an atmoſphere of vital air. Hence, the rapid inflammation of powder, its taking place in cloſe veſſels, and the terrible force with which it explodes and drives every obſtacle before it, may be eaſily conceived [c].

The effects of this mixture of nitre, ſulphur, and charcoal, are nothing, in compariſon with thoſe of another preparation, called *fulminating powder*. This is made, by triturating, in a hot marble mortar, with a wooden peſtle, three ounces of nitre, two ounces of carbonat of potaſh or very dry *fixed ſalt of tartar*, and one ounce of flowers of ſulphur, till the whole is very accurately mixed. If a drachm of this powder be expoſed to a gentle heat, in an iron ladle, it melts, and ſoon after produces a detonation as loud as the report of a cannon. This phenomenon, which is ſo much the more aſtoniſhing, becauſe its effect is produced without encloſing the powder in any inſtrument, as is done with gunpowder, may be explained, by obſerving, 1. That it does not ſucceed, but by gradually heating the mixture, ſo as to melt it. 2. That if fulminating powder be thrown on ignited charcoal, it only fuſes, like nitre, but with very little noiſe. 3. That a mixture of ſulphure of potaſh with nitre, in the proportion of one part of the former, and two of the latter, fulminates with more rapidity, and produces as loud a report, as the compoſition of ſulphur, nitre, and alkali: hence it appears, that when fulminating powder is heated, ſulphure of potaſh is formed before the detonation takes place; and this fact is ſufficient to explain the whole appearance. When cryſtallized nitre, and ſulphure of potaſh are expoſed to the action of heat, ſulphurated hydrogen gas is diſengaged from the latter, while the ſalt gives out vital air. Now theſe two, which together are capable of producing a ſtrong detonation, as we have obſerved in the hiſtory of hydrogen gas, are ſet on fire by a portion of the ſulphur. But as the thick fluid they are obliged to paſs through preſents a conſiderable obſtacle, and as the whole takes fire at the ſame inſtant, they ſtrike the air with ſuch rapidity, that it reſiſts in the ſame manner as the chamber of a muſket reſiſts the expanſion of gunpowder. A proof of this is obſervable in the effect the fulminating powder has on the ladle in which it explodes. The bottom of this veſſel is bulged outwards, and the ſides bent inwards, in the ſame manner as if it had been acted on by a force directed perpendicularly downwards, and laterally inwards, though it may be eaſily conceived that the effect of the exploſion ſhould be directed equally on all ſides or circularly.

Laſtly, We ſhall in this place conſider, that mixture of nitre and ſulphur, which is called *powder of fuſion*. It conſiſts of three parts of nitre, one of ſulphur, and one of ſaw-duſt. A ſmall quantity of this powder is put into a nut-ſhell, with a ſmall piece of copper money rolled up; the piece is covered with the ſame powder, which being ſet on fire, burns rapidly, and melts the coin, without burning the ſhell, which is only blacked. It is neceſſary, however, to plunge the whole in water as ſoon as the powder has ceaſed to burn. This experiment proves, in fact, that the powder is an effectual flux. But as the preſent appearance depends, in a great meaſure, on the action of the ſulphur on the metal, we ſhall again mention this fact in the hiſtory of metallic ſubſtances.

Muriatic, fluoric, and boracic neutral ſalts, have no action on ſulphur. We have ſeen, that alkaline carbonats unite with that ſubſtance, and render it ſoluble in water, by forming the alkaline ſulphures, which retain a ſmall portion of the carbonats.

Hydrogen gas does not act, in any ſenſible manner, on ſulphur in maſs, but it diſſolves it when divided by caloric, forming ſulphurated hydrogen gas. It is proper to obſerve, that it was very natural for chemiſts to conſider theſe ſubſtances, as having a ſtrong analogy with each other. For it is certain that the ſulphuric acid, in its combination with metallic bodies, affords hydrogen gas, when it is diluted with water, and ſulphur, when it is concentrated. In all places where hydrogen gas is produced, as for example, where large quantities of animal matters putrify, ſulphur is likewiſe formed; and the latter, combined with alkaline ſubſtances, appeared to become changed into hydrogen gas. Laſtly, Hydrogen gas acts on a great number of bodies, nearly in the ſame manner as ſulphur. It might therefore have been rationally concluded, that there is a ſort of identity in theſe two bodies, if it were not at preſent known, that hydrogen gas is almoſt always produced by the decompoſition of water, and that ſulphur does not enter into that fluid.

Sulphur is capable of combining with many other ſubſtances; but as thoſe ſubſtances have not yet been treated of, we ſhall poſtpone the conſideration of their properties to the enſuing part of this work.

Sulphur is an excellent remedy in pituitous diſorders of the lungs, and eſpecially in cutaneous diſorders. It is very ſucceſsfully employed in the humid aſthma, and in ſcorbutic eruptions. It is adminiſtered in the form of flowers of ſulphur, or in lozenges prepared with ſugar. An ointment is made with fat ſubſtances, with which cutaneous eruptions are rubbed. Alkaline ſulphures have been propoſed in obſtructions, numbneſs, palſies, foulneſſes of the ſkin, &c. Though ſome phyſicians have ſuppoſed that ſulphur is not ſoluble in the animal fluids, it is neverthelefs certain, that it penetrates to the extremities of the minuteſt veſſels, ſince the perſpiration, the urine, and the ſaliva, of ſuch as uſe it, are manifeſtly impregnated. The ſulphurated hydrogen gas, diſſolved in mineral waters, as in thoſe of Cauterez, Aix la Chapelle, Bereges, and Enghien, communicates to them diſcuſſive properties, of great ſervice in diſorders of the ſkin, the lungs, the joints, palſies, &c.

Sulphur is not leſs uſeful in the arts. We have ſeen its utility in making gunpowder and fire-works. It is uſed to take fine impreſſions of engraved ſtones, to make matches, to bleach ſilks, and to deſtroy certain colours; to impede or ſtop the progreſs of fermentation in wines, &c. It has been propoſed to be uſed in fixing iron in ſtones, &c.

NOTES ON SECTION III.

[P. 136.]

a LAMPADIUS, in expoſing a diamond to the focus of a burning glaſs, in contact with oxygen gas, obſerved that the diamond diſappeared in leſs than five minutes. The diamond, during this combuſtion, exhibited an evident flame, which was not extinguiſhed by a ſtream of oxygen gas. He repeated this experiment on a ſtill larger diamond, and with ſimilar effects. See *Gren's Neues. Journal de Phyſique. Dritter Band. Seite.* 88.

Landriani mentions an experiment in which the diamond was fixed to the end of a ſmall iron wire, which was heated red hot, and plunged into a veſſel containing oxygen gas. The combuſtion of the iron communicated itſelf to the diamond, which burned in this gas with a very bright light. This experiment, however, did not ſucceed with the diamonds from Brazil. See *Annal. de Chem.* Tom. XI. 156.

Mr. Tennant has lately removed all our doubts with regard to the nature of diamond, by a very accurate and ſimple experiment. Into a gold tube, cloſed at one end, he introduced two grains and a half of ſmall diamonds, with a quarter of an ounce of nitre. This tube was expoſed to a ſtrong red heat for about an hour and a half. The air which was extricated during this proceſs contained only a very ſmall quantity of carbonic acid gas. After the tube had become cold, the alkaline matter contained in it was diſſolved in water, and the whole of the diamonds were found to have been deſtroyed. A ſaturated ſolution of marble in muriatic acid was added to the alkaline ſolution. A precipitate of carbonat of lime was inſtantly formed. By adding muriatic acid to this carbonat, a quantity of carbonic acid gas was extricated, which occupied the ſpace of a little more than 10,1 ounces of water.

In a ſecond experiment, made in a ſimilar manner with one grain and a half of diamonds, 6,18 ounce meaſures of carbonic acid gas were obtained. The quantity of carbonic acid, therefore, produced in theſe two experiments, from the combuſtion of the diamond, differs very little from what would have been produced by the combuſtion of an equal quantity of carbon. By combining the carbonic acid obtained from the combuſtion of the diamond with lime, and expoſing it to heat with phoſphorus, it afforded carbon in the ſame manner as any other calcareous carbonat. See *Phil. Tranſ.* for 1797, p. 123.

[b] Some of the more remarkable properties of alkaline ſulphures have been inveſtigated more recently by the Society of Dutch Chemiſts.

By expoſing two equal quantities of freſh ſulphure of potaſh to equal volumes of atmoſpherical air, the one confined by mercury, the other by water, theſe chemiſts obſerved, that at the end of a few days the volume of the air over the mercury was not diminiſhed, while that of the air over the water in the ſame ſpace of time was diminiſhed nearly one fourth. This air, on examination, was found to be completely deprived of its oxygen gas. Effects quite ſimilar were produced by uſing ſulphure of barytes. The abſorption of oxygen gas took place alſo in the air over mercury when the ſulphure had been previouſly moiſtened with a little water. A conſiderable diſengagement of caloric was produced at the moment the water came into contact with the ſulphure.

In expoſing nitrous gas to alkaline ſulphures this gas was deprived of its oxygen in the ſame manner as atmoſpherical air. The dry ſulphures, however, had no action on this gas, but as ſoon as a little water was added, an abſorption of oxygen gas immediately began to take place. Theſe facts were ſufficient to ſhow that the attraction of the ſulphure for oxygen, in theſe experiments, was not exerted directly, but only through the intervention of water. With a view to diſcover the ſhare which water has in producing this abſorption of oxygen gas, a quantity of aqueous vapour was made to paſs through hot alkaline ſulphure, and it was found that ſulphurated hydrogen gas alone paſſed over into the receiver. When muriat of barytes was added to a ſolution of the ſulphure uſed in this experiment, a copious precipitation of ſulphat of barytes took place. This experiment ſhowed that it was the water which had been decompoſed, and that it was the oxygen of this fluid which had united with the ſulphur of the ſulphure to form ſulphuric acid. Sulphure of lime, through which aqueous vapour had been paſſed, afforded the ſame reſults.

Theſe chemiſts, however, were not able to effect the direct combination of ſulphur with hydrogen, by paſſing this gas through alkaline ſulphures in a high temperature.

Sulphurated hydrogen gas was quickly abſorbed by the cauſtic ſolutions of ammoniac, ſoda, and potaſh. Lime water produced the ſame effect, but with leſs rapidity. The ſulphurated hydrogen gas could be ſeparated from the alkali by the addition of an acid in a quantity equal to that which had been abſorbed. Alkalis, in their dry ſtate, did not abſorb this gas; but the addition of a little moiſture occaſioned an immediate abſorption.

When ſulphurated hydrogen gas was brought into contact with ammoniacal gas, a combination took place, and the gaſes were deprived of their elaſticity. The ſulphurated hydrogen gas could be diſengaged by adding an acid, which united with the ammoniac. By expoſing the ſulphurated hydrogenated ammoniac to a ſtrong fire, the ſmoking liquor of Boyle was produced. Carbonic acid ſeemed to deſtroy the affinities of alkalis for ſulphurated hydrogen gas.

The fixed alkalis alſo, ſaturated with ſulphurated hydrogen gas, were found to poſſeſs the property of abſorbing oxygen when expoſed to the atmoſphere; the ſulphur, in combination with the alkali, forming with this oxygen a ſulphat. The oxygen of the water ſeemed to be attracted in preference to that of the atmoſphere. In this caſe the hydrogen of the water has a tendency to combine with the other portion of the ſulphur, and to form ſulphurated hydrogenated gas.

An alkaline ſulphure diſſolved in water contains therefore alkaline ſulphure, properly ſo called, or the ſimple combination of ſulphur with alkali; 2dly, Sulphat of alkali; and, 3dly, Sulphurated hydrogen gas diſſolved in the alkaline ſulphure. It is this ſulphurated hydrogen which abſorbs oxygen from the atmoſphere. When expoſed to that fluid, the hydrogen has a tendency to reſume its oxygen, and to form water, while the ſulphur which had been united to the hydrogen remains in combination with the alkali. But the water thus formed is decompoſed in its turn; and theſe operations go on alternately till every particle of the ſulphure is converted into a ſulphat. *Journ. de Phyſ.* 1792, Vol. I. p. 409.

Berthollet diſtinguiſhes the combinations of ſulphurated hydrogen with alkaline or earthy baſes by the name of *Hydro-ſulphures*.

The hydro-ſulphures of potaſh and ſoda are procured by receiving ſulphurated hydrogen gas in a ſolution of theſe alkalis in water. The alkali is allowed to abſorb an exceſs of the gas, which may be afterwards diſſipated by heat. The hydroſulphures of lime and magneſia are prepared in the ſame manner. When preſerved carefully from the air, theſe hydro-ſulphures are colourleſs; but contact with that fluid gives them immediately a yellow tinge.

In expoſing a ſolution of ſulphure of potaſh to the action of ſulphurated hydrogen, Berthollet obſerved that a great part of the ſulphur was precipitated. Water impregnated with ſulphurated hydrogen produced alſo the ſame effect.

The affinities of the earthy and alkaline baſes for ſulphurated hydrogen have been but very curſorily examined. Berthollet thinks that barytes has the ſtrongeſt affinity, alumine little or none. When hydro-ſulphure of potaſh or of ammoniac is mixed with an acid ſolution of lime, magneſia, or barytes, no precipitation takes place, either becauſe there is no exchange of baſes, or becauſe the reſults of the new combinations are all ſoluble in water. The ſolution of alumine is precipitated, and Berthollet propoſes this as a convenient method of ſeparating alumine from other earths diſſolved in acids.

Sulphurated hydrogen diſſolved in water reddens the tincture of turnſole. Its combinations with alkalis and earths produce a decompoſition of metallic ſolutions. This ſubſtance decompoſes ſoap, precipitates ſulphur from alkaline and earthy ſulphures, and forms with the alkali or earth a triple combination. But as theſe are the properties by which acids are characterized, Berthollet is of opinion that ſulphurated hydrogen ought to be ranked among that claſs of ſubſtances.

In order to determine whether ſulphurated hydrogen be formed at the moment water is added to a ſulphure, or whether the action of an acid contributes to its formation, Berthollet made the following experiment.

Dry ſulphure of potaſh was diſſolved in alcohol, and ſulphat of potaſh was formed. On mixing the liquor, which was of a very deep colour, with diſtilled water, it became muddy, and depoſited a conſiderable quantity of ſulphur. To this liquor, after it had been allowed time to ſettle, he added muriatic acid; by which a large quantity of ſulphurated hydrogen gas was diſengaged, and the remainder of the ſulphur precipitated. A ſolution of muriat of barytes, poured into this liquor, did not diſturb its tranſparency; a proof that neither the ſulphuric nor ſulphureous acids are formed when a ſulphure is decompoſed by muriatic acid. From this experiment, Berthollet concludes that the ſulphurated hydrogen is produced from the decompoſition of the water furniſhed by the alcohol, and that the action of the acid conſiſts merely in giving a gazeous form to the product, by the caloric which it diſengages.

A ſolution of hydro-ſulphure of alkali diſſolves ſulphur in the cold. If oxygenated muriat of potaſh be added to a ſolution of ſulphure of potaſh, ſulphur will be precipitated. The ſulphurated hydrogen, in this experiment, is deſtroyed by the oxygen of the muriatic acid and the ſulphur precipitated, becauſe the alkali has a greater attraction for the water than for the ſulphur. The union, therefore, between a ſulphure and water is produced ſolely through the intermedium of ſulphurated hydrogen. To the combination of the hydro-ſulphure of alkali with ſulphur, Berthollet gives the name of *hydrogenated ſulphure.* The combination of alkalis, therefore, with ſulphur, according to this nomenclature, are either *ſulphures*, *hydro-ſulphures*, or *hydrogenated ſulphures.*

In the diſtillation of ſulphure of ammoniac, it is only the liquor which comes over firſt that is ſmoking. Berthollet added ſome muriatic acid to equal portions of the ſmoking and of the unſmoking liquors obtained in this diſtillation, and of hydro-ſulphure of ammoniac; very little ſulphurated hydrogen was evolved from the ſmoking liquor, and only a ſmall portion of ſulphur depoſited. The acid diſengaged more of the ſulphurated hydrogen gas, and of ſulphur, from the unſmoking liquor. A much more conſiderable quantity of ſulphurated hydrogen gas was diſengaged by this acid from the hydro-ſulphure of ammoniac; but this diſengagement was unaccompanied by any depoſition of ſulphur. By mixing nearly equal parts of ammoniac with the unſmoking liquor, and with the hydro-ſulphure of ammoniac, theſe two liquors immediately began to fume, and to reſemble, in their colour and other qualities, the ſmoking liquor which comes firſt over in diſtillation. Berthollet, from this experiment, is inclined to aſcribe the ſmoking quality of the liquor to the preſence of a portion of uncombined ammoniac.

Sulphure of ammoniac is capable of diſſolving a conſiderable quantity of ſulphur in the cold. In the fuming ſtate, it diſſolves a quantity of ſulphure ſufficient to ſaturate the exceſs of ammoniac, and ceaſes to be fuming. The ſulphure of ammoniac, ſaturated with ſulphur, has a deep colour and oily conſiſtence. Sulphurated hydrogen does not produce in it any precipitation of ſulphur; but this ſubſtance is depoſited by the contact of air, which acts immediately on the hydrogen. The ſolution of ſulphur in ſulphure of ammoniac forms, then, according to the nomenclature of Berthollet, an hydrogenated ſulphure of ammoniac.

When muriatic acid is added to an hydrogenated ſulphure of alkali, a ſmall quantity of ſulphurated hydrogen gas is produced; but while the greater part of the ſulphur is ſeparated, there is another portion of it which combines with the ſulphurated hydrogen, acquires an oily appearance, and ſinks to the bottom of the veſſel in which the experiment is made. This combination Berthollet terms Hydrogenated Sulphur. It was Scheele who firſt obſerved the formation of this hydrogenated ſulphur; but ſince his time it has not been mentioned by any chemiſt.

Hydrogenated ſulphur gives out ſulphurated hydrogen gas when expoſed to the action of a gentle heat. Contact with air alſo ſpeedily diſengages this gas. In both theſe caſes, the hydrogenated ſulphur gradually loſes its fluidity, and is at laſt changed into pure ſulphur. A ſmall degree of heat is produced by mixing potaſh with hydrogenated ſulphur, and a ſmall quantity of ſulphurated hydrogen diſengaged from that portion of the hydrogenated ſulphur which does not combine with the alkali. The remainder combines with the alkali, and forms an hydrogenated ſulphure of potaſh.

Sulphurated hydrogen gas is not decompoſed by oxygen gas in the ordinary temperature of the atmoſphere. It is the ſame when this gas is diſſolved in water. In the latter caſe, the air attracts it from the water in which it is diſſolved; it is not ſo with the hydro-ſulphures. When pure, theſe ſubſtances have no colour, but they receive a yellow tinge from the action of air.

If to a colourleſs hydro-ſulphure, ſulphuric, muriatic, or any other acid, be added, which has no action on hydrogen, ſulphurated hydrogen gas will be diſengaged, without any depoſition of ſulphur; but if the hydro-ſulphure has become coloured, a depoſition of ſulphur will take place in proportion to the changes which the ſulphurated hydrogen has already undergone. It is the hydrogen, therefore, which is firſt diminiſhed in the decompoſition of ſulphurated hydrogen. In combining with the oxygen of the atmoſphere to form water, it quits the ſulphur, but a portion of the ſulphur is ſoon changed into an acid; and when the ſulphurated hydrogen has been reduced to a certain point, the oxygen acts equally in decompoſing it upon the hydrogen and the ſulphur.

If an hydrogenated ſulphure be expoſed to the action of the air, it abſorbs oxygen, which acts on the hydrogen and ſulphur. In proportion as hydrogenated ſulphur is decompoſed, there is a depoſition of ſulphur produced; but in the decompoſition of a hydro-ſulphure, no depoſition whatever takes place.

It is the ſulphuric, and not the ſulphureous acid which is formed, when water is decompoſed, to produce ſulphurated hydrogen, but it is the ſulphureous acid which is formed by the ſpontaneous abſorption of oxygen from the atmoſphere. In the former caſe the oxygen is more completely deprived of its caloric, and conſequently diſpoſed to enter into a cloſer union.

Sulphureous acid, in contact with ſulphurated hydrogen, yields its oxygen to the hydrogen; and the ſulphur contained in the ſulphureous acid, as well as that in the ſulphurated hydrogen, is precipitated.

Nitric acid alſo decompoſes ſulphurated hydrogen, by yielding its oxygen to the hydrogen. But this action of the nitric acid is deſtroyed, or, at leaſt, greatly weakened, by diluting it with water. *Ann. de Chem.* Tom. XXV. p. 233.

[c] The explanation given by Fourcroy of the exploſive effects of gunpowder is rendered extremely doubtful by the late ingenious and difficult experiments which Count Rumford has made upon this ſubject, of which a very minute account is to be found in the volume of the *Philoſophical Tranſactions* for the year 1797.

By contriving to fire gunpowder in an apparatus, in which the elaſtic fluid generated was made to act with a determined force againſt a weight capable of being increaſed or diminiſhed at pleaſure, the Count was enabled to calculate the force which this fluid exerts with a very tolerable degree of accuracy. In ſome experiments this force amounted to no leſs than 412529 lbs. a force 55004 times greater than the mean preſſure of the atmoſphere. When the weight was increaſed ſo as to confine the elaſtic fluid for a few minutes after the inflammation of the powder, it was found to poſſeſs only a very ſmall degree of expanſive force; for on raiſing the weight, the fluid ruſhed out with a noiſe hardly ſo loud or ſharp as the common report of an air gun. It became obvious from this and ſimilar experiments, that the quantity and force of the permanently elaſtic fluid generated were by no means adequate to explain the phenomena. Count Rumford was therefore led to ſearch for the cauſe of theſe phenomena, in the temporary action of a fluid not permanently elaſtic; and this fluid he conceived to be water, which had been converted into vapour by the caloric evolved during the combuſtion of the inflammable materials of which gunpowder is compoſed. Two conditions only ſeemed to be required to render this ſuppoſition probable; 1ſt, The exiſtence of a ſufficient quantity of water in gunpowder; and, ſecondly, The evolution of a quantity of caloric not only ſufficient to convert this water into ſteam, but alſo to raiſe its temperature in that ſtate to a very conſiderable degree.

The firſt condition is found in the quantity of water actually contained in gunpowder, which from experiment appears to amount to fifteen grains of this fluid in every cubic inch of the powder. The ſecond condition is to be ſought for in the actual degree of heat, which is excited during the inflammation of gunpowder, and the effects which this degree is known to have of increaſing the expanſive force of aqueous vapour. With regard to the degree of heat, it may be remarked, that braſs has been known to melt in the heat generated during the combuſtion of gunpowder, when this metal was previouſly reduced to very ſmall particles, and mixed with it. Now, this metal, according to Wedgewood, melts only in a degree of heat equal to 3807. It is alſo a well known fact, that the elaſticity of aqueous vapour is incomparably more increaſed by any given increaſe of temperature than that of any other ſpecies of elaſtic fluid. But as the elaſticity or expanſive force of this fluid at the temperature of 212°, is equal to the ordinary preſſure of the atmoſphere; and as this elaſticity is doubled by every increaſe of temperature equal to 30° of Fahrenheit, it becomes eaſy to calculate what the prodigious force of this vapour muſt be when raiſed to the temperature of 3807°.

CHAPTER V.

GENUS V. METALLIC SUBSTANCES IN GENERAL.

METALLIC ſubſtances conſtitute an order of bodies, of the greateſt importance and utility in the different purpoſes of ordinary life, as well as in chemiſtry and medicine. They eſſentially differ from earthy and ſaline matters, by their phyſical characters, and their chemical properties.

Before we proceed to the examination of each particular metallic ſubſtance, it will be proper to conſider them in general. We ſhall do this in order, under ſeveral heads; namely, 1. We ſhall ſpeak of their phyſical properties. 2. Their natural hiſtory. 3. The art of aſcertaining their nature and quantity, which is uſually called the docimaſtic art, or art of aſſaying. 4. The art of working metals in the large way, or metallurgy. 5. Their chemical properties. 6. The method of diſtinguiſhing them from each other, and the diviſions which it is neceſſary to eſtabliſh among them.

§ I. *Concerning the Phyſical Properties of Metallic Subſtances.*

Metallic ſubſtances are abſolutely opapue; a circumſtance in which they differ greatly from ſtoney ſubſtances: for the moſt opaque ſtone, being divided into thin portions, has a ſort of tranſparency; whereas the thinneſt plate of metal is as perfectly opaque as the moſt ſolid piece *. The opacity of metallic ſubſtances, renders them exceedingly proper to reflect the rays of light, no bodies poſſeſſing this property in ſo eminent a degree. Thus we obſerve, that looking-glaſſes do not ſtrongly reflect the ſpecies of objects, unleſs they be coated with metal. The metallic brilliancy ariſes from the ſame property, and is always greater, in proportion as the denſity and hardneſs of the metal permits it to take a finer poliſh. White metallic ſubſtances reflect a greater quantity of light, and are more brilliant than thoſe which are coloured.

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* This has not been well inquired into. Gold in leaf, which is about the $\frac{1}{180500}$ of an inch in thickneſs, tranſmits light of a lively green colour, and is tranſparent. Silver leaf, which is about the $\frac{1}{160000}$ of an inch thick, is perfectly opaque; and ſo likewiſe is leaf braſs, or Dutch gold, whoſe thickneſs is $\frac{1}{80000}$ of an inch. Other metals have not been extended in this way, and whether any of them are capable of it in any conſiderable degree, is not known. T.

Metallic ſubſtances have a much greater ſpecific gravity than all other bodies. A cubic foot of marble weighs only 252 pounds; a cubic foot of tin, which is the lighteſt of metals, weighs 516 pounds; and a cubic foot of gold weighs 1326 pounds. This exceſſive weight, ſo much beyond that of other earthy ſubſtances, doubtleſs depends on their great denſity, to which their perfect opacity and brilliancy are likewiſe owing.

Moſt metallic ſubſtances may be extended, by repeated percuſſion, or ſtrong preſſure. This property, peculiar to metallic matters, and which for that reaſon we have not had occaſion to notice in any of the ſubſtances we have yet examined, is termed *ductility.* We think it ought to be diſtinguiſhed into two kinds; the one, ductulity under the hammer, or *malleability*, conſiſts in the property of being extended into thin plates, without cracking; lead and tin poſſeſs this kind of ductility only: the other conſiſts in the ſucceſſive, and almoſt extreme lengthening of certain metallic matters into wire. This ductility, which is eminently obſervable in iron, copper, and gold, is likewiſe called *tenacity.* It is of much more conſequence to make a proper diſtinction between theſe two ſorts of ductility, becauſe they appear to be really verydifferent from each other. Metallic ſubſtances, which are very malleable, have often ſcarcely any tenacity; and many of thoſe which are very ductile, when in the hand of the wire-drawer, are not very malleable. The tenacity of metals is very accurately expreſſed, by the quantity of weight a metallic wire, of a known diameter, is capable of ſuſtaining without breaking: both theſe properties appear to depend on the peculiar form of the integrant parts of each metal. Metals, which are extended into thin plates by percuſſion, ſeem to be formed of ſmall laminæ, which, when compreſſed, ſlide on each other, and are increaſed in breadth, in proportion as their thickneſs is diminiſhed; while ſuch as are capable of being drawn into fine wire, have a kind of fibrous texture, whoſe filaments are cauſed to approach each other, and become lengthened, by the ſtrong preſſure they ſuffer in the drawing. The ductility of metals is limited. It is obſerved, that when a metal, even of the moſt ductile kind, has received ſeveral ſtrokes of the hammer, it becomes hard, and cracks, inſtead of extending; it is then ſaid to be *hammer-hardened*: a metal in this ſtate, recovers its former ductility, by being heated, and gradually cooled. The parts ſeem to extend under the hammer, only while the ſpace between each particle is ſuch, that they may yield before the hammer. It may eaſily be conceived, that theſe parts, being once brought ſufficiently near each other to leave ſcarcely any interval, can no longer yield or eſcape before the ſtroke of the hammer; and in that caſe, the impulſe will be exerted in deſtroying the texture, or breaking the metal. Heat, by dilating, cauſes the parts to ſeparate, and produces new ſpaces between them, which conſequently allow of their being again brought together, by reiterated ſtrokes.

As ductility is a property of certain metallic ſubſtances only, chemiſts and naturaliſts have availed themſelves of it as a diſtinctive character. They call thoſe which have the metallic weight and brilliancy, together with ductility, *metals*; and thoſe which, with the metallic appearance, are not ductile, they call *ſemi-metals*. But this diſtinction, though conſiderably accurate, is not ſufficient to ſeparate all metallic matters into two claſſes, ſince the difference between the extreme ductility of gold, and the ſingular brittleneſs of arſenic, is connected by inſenſible degrees in the other metals; there being perhaps a greater difference, in this reſpect, between gold and lead, which are reckoned metals, than between lead and zinc, the latter of which is reckoned among the ſemi-metals; or between zinc and arſenic: beſides, the term ſemi-metal expreſſes a very hypothetical opinion reſpecting the nature and formation of metals.

Metals, conſidered with reſpect to their ductility, may be arranged in the following order. Gold is the moſt malleable, and is ſucceeded in order by ſilver, copper, iron, tin, and lead. The ſemi-metals have been conſidered as poſſeſſing no ductility. We ſhall, however, ſee, that this property exiſts, in a certain degree, in zinc and mercury. As to tenacity, gold poſſeſſes it in the higheſt degree, and is ſucceeded by iron, copper, ſilver, tin, and lead. The tenacity of platina is not well known.

Metallic ſubſtances are ſuſceptible of a regular figure, either naturally, or by art. Naturaliſts have long acknowledged this property in native biſmuth, virgin ſilver, and ſome other metals. The alchemiſts have carefully obſerved the ramified, or ſtellated figures, which are formed at the ſurface, of antimony, and biſmuth. Baumé, in his Chemiſtry, affirms, that metallic matters, after being well fuſed, aſſume a ſymmetrical arrangement, by gradual cooling, &c. The Abbé Mongez, who accompanied La Peyrouſe in his voyage round the world, has made a continued ſeries of experiments on the cryſtallization of all metallic ſubſtances. Brongniart, lecturer of chemiſtry at the botanic garden, has likewiſe made experiments relative to this inquiry, which have been repeated by many chemiſts. The general reſult is, that all metals are capable of cryſtallizing, and that though many of them apparently differ, yet the greateſt number preſents the ſame octahedral form, with ſome modifications.

Certain metallic matters have a ſenſible taſte and ſmell, as arſenic, lead, antimony, copper, tin, and iron. Theſe properties are conſtantly obſerved in ſuch metallic ſubſtances as are moſt ſubject to change. They ſometimes exiſt in ſo eminent a degree, as to be capable of corroding, and entirely deſtroying the organs of animals [a].

§ II. *The Natural Hiſtory of Metallic Subſtances.*

Metallic ſubſtances exiſt in the earth in four different ſtates: the firſt is that of virgin, or native metal; that is to ſay, poſſeſſed of all its properties. Gold is always found in this ſtate; ſilver, copper, mercury, biſmuth, and arſenic, often; but iron ſeldom: and lead, zinc, antimony, &c. ſtill more rarely.

The ſecond ſtate in which metallic ſubſtances are found, is that of oxyds or *calces*, that is to ſay, without the metallic aſpect, and rather reſembling ochres, or earthy ſubſtances. Copper is often found in the ſtate of green or blue oxyd; iron in that of a yellow, red, or brown oxyd; lead, in the ſtate of a white, grey, or reddiſh oxyd; zinc in the ſtate of calamine; cobalt in red flowers; arſenic in a white oxyd, &c.

The third natural ſtate, and the moſt common in which metals are found, conſtitutes ores, or mineralized metals. The metallic ſubſtance is found combined with a combuſtible matter, which deprives it of its metallic properties, and requires to be ſeparated before thoſe properties can be again manifeſted. This matter, which is called the *mineralizer*, is either ſulphur, or ſome metal. Some chemiſts even affirm that ſulphur is the moſt common mineralizer. It is united to ſilver in the vitreous ore of ſilver; ores of copper almoſt almays contain much ſulphur; iron is combined with this mineral in the martial pyrites, lead in the galena, mercury in cinnabar, zinc in blend; and laſtly, it is ſometimes united with biſmuth, and often with arſenic.

It is proper to obſerve, that metals have not all the ſame affinity with ſulphur. There are ſome metals which contain large quantities, and readily part with it, their metallic ſtate appearing ſcarcely altered; ſuch are copper, lead, and antimony. Others contain it in very ſmall quantities, but ſtrongly adherent, and cauſing almoſt all the metallic qualities to diſappear; as is obſervable in cinnabar.

Metals are occaſionally found alloyed with other metals, but arſenic is the moſt uſual mineralizer. Iron, tin, and cobalt, are frequently united to arſenic. Sometimes the metal is combined both with arſenic and with ſulphur, as in the red ore of antimony, and the red ſilver ore. Laſtly, There are metallic ores compoſed of ſeveral metals and ſeveral mineralizers; ſuch as the grey copper ore, the grey ſilver ore, and ſome others.

The fourth ſtate in which metals are found, is in combination with ſaline ſubſtances, almoſt always acids. The ſulphuric acid is moſt frequently found combined with metals; as for example, the oxyds of zinc, lead, copper, and iron, are often in the ſtate of ſulphats. The carbonic acid is likewiſe a common mineralizer; and the muriatic, arſenic, and phoſphoric acids have likewiſe been diſcovered in minerals within the laſt few years.

Metallic ſubſtances are much leſs abundant than ſtoney matters; they are formed in mountains in veins or clefts, which interſect the ſtrata of earths and ſtones with various degrees of obliquity. This is the moſt uſual ſtate of mineralized metals; ſuch as are in the ſtate of oxyds, or of ſalts, are often found in maſſes depoſited by water, and ſometimes cryſtallized. Metallic ores are alſo found in large irregular maſſes; in this caſe, their formation ariſes from peculiar cauſes.

The metallic veins are accompanied with ſtoney matters, which ſeem to have been formed at the ſame time. Theſe ſtones are uſually quartz and ſpar. They form two layers; the layer on which the ore is placed is called the *bed* or *floor* of the mine; the other which covers it is called the *roof*. Stones conſtitute what is called the *gangue* or *matrix* of the ore, and muſt not be confounded with the mineralizer; for this laſt is combined with the metal, ſo as not to be ſeparated but by chemical methods; whereas the gangue may be ſeparated by mechanical means. Neither muſt the gangue, which is formed of cryſtallized ſtones, be confounded with the rock which forms the maſs of the mountain wherein the metallic veins are formed. The veins are divided into rich, or poor; large, or ſmall; ſtraight, or crooked; continued, or interrupted.

Metallic ſubſtances appear to be all formed by water. The greater part, in fact, are found cryſtallized, or mixed with ſubſtances incapable of ſuſtaining the action of fire without change; as calcareous ſtones and ſulphur. Bodies are likewiſe found among them which have the animal or vegetable organization; a certain proof that they have not paſſed the fire. There may, perhaps, exiſt certain ores, whoſe formation may be attributed to fire; as for example, the ſpecular iron ore of Mont d'Or in Auvergne, and that of the Iſle of Elba; but theſe inſtances are rare.

Ores are more commonly found in mountains than in plains; and almoſt always in ſuch mountains as form continued chains. It is obſerved that the plants which grow on the ſurface of metalliferous mountains, are dry; the trees are ſinuous, and deformed; ſnow melts almoſt immediately when it falls in theſe regions, and the ſands often exhibit metallic colours. Mineral metallic ſprings are found in the vicinity; by the examination of which, and of the ſands over which they flow, good indications of the metallic matters in the neighbourhood may be obtained. When metallic veins appear at the ſurface of the earth, the ground may be broken into with probability of advantage, and the boring inſtrument bringing up the ſubſtances which compoſe the internal parts of the mountain, together with the metallic mineral ſubſtance, ſerves to ſhow the nature of that ſubſtance, as well as the reſiſtance which may be expected in digging.

§ III. *The Art of Aſſaying Ores, or Docimaſia.*

When a certain quantity of any ore has been extracted, it is neceſſary to make an aſſay, that its nature and produce may be known. Theſe aſſays form one of the moſt important parts of chemiſtry, which we term the *docimaſtic art.* They require to be varied according to the nature of the ore under examination; though there are certain general principles to be followed in all aſſays.

Specimens of the ore are to be taken from the richeſt, the pooreſt, and that which is of a middle quality. This precaution is very neceſſary; becauſe if the aſſay were made with a rich ſpecimen, it might excite too flattering expectations; or if with a very poor one, it might produce diſcouragement. The ores being finely powdered, muſt afterwards be thoroughly waſhed with water, which carries off the pulverized gangue, while the more ponderous mineral remains at the bottom of the veſſel. The waſhed ore muſt then be carefully roaſted, in order to drive off, by ſublimation, as large a quantity as poſſible of the mineralizer. The roaſting ought to be performed in a ſmall ſhallow earthen diſh, covered with a veſſel of the ſame kind. This precaution is neceſſary, becauſe certain ores decrepitate in the fire, and would fly out of the capſule in which they are roaſted, and by that means render the reſult uncertain. As the roaſting made in the open air uſually leaves the metal in the ſtate of an oxyd, and may even diſſipate a part, if it be of a volatile nature; we prefer the roaſting of ores in an earthen retort. This operation, although more tedious and difficult, has the advantage of exhibiting the nature and property of the mineralizer, and of affording a much more accurate analyſis of the mineral. When the ore has been kept red hot for a certain time, and no longer emits any vapour, the roaſting is finiſhed. The ore being weighed before and after the waſhing, determines the quantity of the gangue; a ſecond weighing after the roaſting, ſhows how much it loſes by that operation.

The roaſted ore muſt then be fuſed. For this purpoſe, it is mixed with three parts of black flux, and a ſmall quantity of decrepitated muriat of ſoda, and put into a crucible cloſed with its cover, and placed in a good melting furnace. The alkali of the black flux fuſes the metal, and abſorbs the portion of mineralizer which remains in the ore. The coal of the tartar which exiſts in the black flux ſerves to reduce the oxyd of the metal, by abſorbing its oxygen. The muriat of ſoda prevents the mixture from ſuffering any loſs during the fuſion; becauſe that ſalt, being lighter than the other matters, occupies the upper part of the crucible, and covers the mixture. The fuſion being performed, the crucible muſt be ſuffered to cool very gradually. When the fuſion has been properly made, the metal is found in a ſingle button with a convex ſurface, and no metallic grains are diſcovered in the ſcoriæ; the ſcoriæ themſelves being vitreous, compact, and uniform, covered with a bed of common ſalt melted into a ſolid maſs. The metallic button muſt be accurately weighed, and ſhows the proportion of metal contained in the ore.

Some ores are harder, and more refractory; to theſe muſt be added, a larger quantity of the moſt active fluxes, ſuch as borax, pounded glaſs, fixed alkalis, &c. It frequently happens, that the ſame mineral contains the perfect metals mixed with the imperfect; theſe are ſeparated by heating the metallic button with contact of air. The imperfect metal is diſſipated by oxydation, and leaves the perfect metal in a ſtate of purity. This operation is generally termed *affinage*, or *refining*. The perfect metal almoſt always conſiſts of gold and ſilver mixed together. Theſe are ſeparated by diſſolving the ſilver in a menſtruum, which does not act upon the gold, the operation being called parting. The reſidues of all theſe proceſſes muſt be weighed with the aſſay balance.

Theſe proceſſes, accurate as they may ſeem, are often leſs uſeful to thoſe who undertake to work mines than an aſſay leſs carefully conducted would be; becauſe, in the large way, neither the ſame expenſive materials are uſed, nor the ſame minute accuracy obſerved. It is therefore proper to attempt to fuſe the ore among the coals of a melting furnace. The charcoal reduces the metallic oxyd; and the fixed alkali produced in the combuſtion of the charcoal, abſorbs a portion of the mineralizing ſubſtance. It is ſometimes neceſſary to add a ſmall quantity of iron filings or ſcoriæ, or glaſs gall, to facilitate the fuſion of the more refractory ores.

There is likewiſe a method of aſſaying in the humid way, which may be practiſed when it is required to know what metals are contained in ſpecimens intended to be preſerved in cabinets of natural hiſtory. A ſmall piece of the ore is taken, which is digeſted in acids, that diſſolve the metal, and ſeparate the mineralizer; the ſalt produced by the union of the metal to the acid, ſhows the quality of the metal: but this kind of aſſay is not applicable to every ore, becauſe they are not all capable of being attacked by acids. Bergman has written a very valuable diſſertation on this method of analyſis, which may be conſulted *.

§ IV. *Concerning the Art of extracting and purifying Metals in the large Way, or Metallurgy.*

When by the aſſay of an ore it is aſcertained that it is worth working, the operation is conducted in the following manner: A ſquare perpendicular well, or cavity, is dug in the earth, of ſufficient magnitude to contain ladders, by means of which the workmen may deſcend and aſcend. Over this is uſually erected ſome ſimple apparatus for drawing up veſſels loaded with the mineral; and ſometimes pumps are erected to draw up the water which may iſſue from the earth into the cavity. If the ore is too deep for one ſingle well, or ſhaft, to lead to the floor of the vein, a horizontal drift is dug, at the end of which a new ſhaft is ſunk; and this is done repeatedly, till the works are carried to the required depth.

If the rock in which theſe operations are carried on be very hard, it will not be neceſſary to ſupport it; but if it be crumbly, as when the work is carried on through earths, the drifts muſt be properly ſupported, and the ſhafts lined with planking properly fixed.

It is of great conſequence to renew the air in mines. When it is practicable to open an adit from the bottom of a ſhaft, ſo as to communicate horizontally with the plane below, a current of air is eaſily produced; but where this cannot be done, a new ſhaft is ſunk, ſo as to communicate with the end of the gallery, fartheſt from the original ſhaft. When one of theſe two ſhafts is lower than the other, the air circulates readily; but if both open at the ſame level above, no current of air will be produced. In this laſt caſe, a fire is lighted in a furnace at the mouth of one of the ſhafts, and the air being rarified by the heat, paſſes through the combuſtible matters, and is continually renewed in the gallery.

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* See Bergman's Eſſays, tranſlated by Cullen.

Water is likewiſe productive of great inconvenience in mines. If it iſſues by a little at a time from the earths, the miners attempt to convey it to ſome lower ground, or to the neareſt river, by a ſloping drift. If it is collected in larger quantities, pumps are uſed to draw it off. It ſometimes happens, in piercing the rock, that a prodigious quantity of water, capable of filling all the drifts, iſſues out in an inſtant. The workmen are aware of this, by the particular kind of noiſe produced, in ſtriking their inſtruments againſt the rock. In this caſe, they conſtruct a door, or gate, in one of the galleries; a workman breaks the rock to give vent to the water, and quickly retires, ſhutting the door after him; by which means, he has time to eſcape before the water gains too much.

Vapours of carbonic acid, and hydrogen gas, are often diſengaged, or formed in mines, by the re-action of mineral and metallic matters on each other. The fires which the workmen are obliged to light for the purpoſe of ſoftening or ſplitting the rock, favour the diſengagement of theſe gaſes; whoſe dangerous effects can only be prevented by rapid currents of air, or by detonation.

The ore extracted from the earth is pounded, waſhed, roaſted, ſmelted, and refined. The ore is in ſome caſes pounded under large peſtles, moved by water; and the pounded ore is waſhed on inclined planes or tables, by the current of water which carries off the gangue. Ores that contain much ſulphur muſt be roaſted in the open air; ſuch as contain but little, may be roaſted in the furnaces, which afterwards ſerve to fuſe them. Some ores are fuſible alone; others require to be melted in contact with charcoal, and with different fluxes. The melting furnaces vary in different countries, and according to the nature of the ore. The refining furnaces do not eſſentially differ from thoſe uſed in melting; and ſometimes the ſame furnace ſerves for both operations. When the metals have been reduced in this manner, they almoſt always conſiſt of ſeveral united together. The methods of ſeparating them are entirely chemical, and will be ſpoken of when we come to treat of each metal individually.

§ V. *Concerning the Chemical Properties of Metallic Subſtances.*

All the chemical properties of metallic ſubſtances ſeem to prove, that they are ſimple, and not decompoſable. The changes they are ſubject to by the action of heat, air, and ſaline ſubſtances, always ariſe, as we ſhall ſee, from combinations; none of theſe changes reſembling an analyſis, as we ſhall prove by a particular explanation of the phenomena which accompany them.

Light appears to alter the colour and the brilliancy of ſome metallic ſubſtances. Though well cloſed in tranſparent veſſels, they become tarniſhed by a change of colour, which gradually increaſes till the metallic brilliancy no longer remains. This kind of alteration has not been obſerved to any farther extent.

Heat only produces certain changes of aggregation, with various degrees of facility in each. All metallic ſubſtances heated in well cloſed veſſels become fluid, or melt; ſome long before the red heat, others at the inſtant of ignition; and others long after. No two metals perfectly agree in fuſibility. If they be ſuffered to cool gradually, after having been melted, they cryſtallize. If the fire be greatly urged, they boil after the manner of fluids, and are reduced into vapours. Theſe properties have long been known in mercury; many goldſmiths have aſſured me that they have obſerved gold and ſilver to boil when in fuſion. Buffon obſerved, that when plates of ſilver are expoſed to the focus of a large concave mirror, a white fume is emitted from their ſurface. Macquer and Lavoiſier, having placed cuppelled ſilver in the focus of the lens of Tſchirnhauſen, obſerved, that this metal exhales in the form of ſmoke. A plate of gold expoſed to this fume was perfectly ſilvered. Gold placed in the ſame focus likewiſe emitted fumes, which perfectly gilded a plate of ſilver expoſed to them. The chimneys of goldſmiths and aſſayers are filled with fumes of gold and ſilver. Copper, tin, lead, zink, antimony, biſmuth, and arſenic, are volatilized with conſiderable facility.

All melted metals appear convex on their ſurface, and form perfect ſpheres when their quantity is ſmall. This effect depends on the force of aggregation, which cauſes the metallic parts to approach each other, and likewiſe on their ſmall tendency to combine with the body which ſupports them. This property is general in all fluids, and may be obſerved in oil, ſurrounded with water, or water ſurrounded by any fat ſubſtance.

Metals expoſed to the action of fire with contact of air, are very ſenſibly altered; but the time required to produce thoſe alterations is exceedingly different in the ſeveral metals. Such as are not ſenſibly changed, are called *perfect metals*; and ſuch as are entirely deprived of their metallic properties by this proceſs, are called *imperfect metals*. This change, to which metallic ſubſtances are liable, is called oxydation, and is a true combuſtion; which cannot be performed without the acceſs of air, and when performed in a certain quantity of air, cannot be continued, unleſs that air be occaſionally renewed. The air in which metals have been burned becomes mephitic. The combuſtion of metallic ſubſtances is accompanied with a flame more or leſs ſtrong, which is very ſenſible in zink, arſenic ,iron, gold, ſilver; and even in lead, tin, and antimony, when ſtrongly heated. Metals in a more eminent degree loſe their metallic properties, the longer they are expoſed to heat in contact with air. Some approach in their characters to earthy matters, in which ſtate they have been called metallic earths or calces. The name of metallic oxyds ought to be preferred to this laſt term, becauſe it is now aſcertained that thoſe burned metals are not earths, as was till within a few years paſt believed, but combinations with oxygen. Metallic oxyds do not retain the brilliancy and fuſibility they poſſeſſed when in the form of metals, and have no affinity with metals, not excepting even the ſpecies from which they were made. When urged by fire, they are either volatilized, or flow into glaſs, which is the more tranſparent and refractory, the more perfect the oxydation. Metallic oxyds or glaſſes unite with ſaline and earthy matters. Several of them have the ſaline character. Arſenic, well oxydated, becomes a peculiar acid, whoſe properties have been examined by Scheele and Bergman. Rouelle has informed us, that the oxyd of antimony, like that of arſenic, is ſoluble in water.

Some metallic oxyds, expoſed to the action of heat, are reduced to the metallic form, affording at the ſame time an aeriform fluid, which is pure vital air. We are indebted to Bayen for the firſt information reſpecting this ſubject. He obſerved, that the oxyds of mercury heated in cloſe veſſels give out much air, and are reduced into running mercury. Dr. Prieſtley having examined this air, perceived that it was much purer than the air of the atmoſphere; and from this diſcovery it is, that we may date the epocha of the commencement of that accurate knowledge we at preſent poſſeſs, reſpecting the calcination of metals. Let us take a ſhort review of the phenomena of this calcination: A metal never becomes calcined, but when in contact with air; the more extenſive this contact, the larger is the quantity of metal which becomes calcined. A given quantity of air can ſerve for the calcination of no more than a given quantity of metal, as Lavoiſier has ingeniouſly proved by calcining lead with a reflecting mirror in a glaſs veſſel, containing a known bulk of air. The metal, during its calcination, abſorbs a portion of the air which ſurrounds it, as is proved by the aſcent of the mercury during the proceſs. The increaſe of weight acquired by the metallic oxyds is owing to this portion of air abſorbed during calcination; for when it is extracted from the oxyds of mercury, they loſe the exceſs of weight in their return to the metallic ſtate; and this exceſs is accurately found in the air they afford by diſtillation. From all theſe phenomena, it appears to be demonſtrated, that calcination is merely the combination of the metal with the baſe of pure air or oxygen contained in the atmoſphere. This combination is often made by the ſimple contact of air and of water, in metals which calcine or ruſt. The neceſſity of heating moſt metals, in order to oxydate them, ariſes from the force of affinity or combination being increaſed in the ſame proportion as the force of aggregation is diminiſhed, whence the change intended to be effected is greatly promoted. Heat, therefore, in this operation, as in many others, is only an acceſſary. The air, which has ſerved the purpoſe of calcination, cannot maintain combuſtion, becauſe it is deprived of that portion of pure or vital air which it contained, and which alone is capable of maintaining combuſtion and life. The greater the quantity of pure air contained in the atmoſphere, the better adapted it is to oxydate a given quantity of metal in a ſhorter time. I have often obſerved, that a much greater quantity of the oxyd of lead, biſmuth, &c. may be obtained by plunging theſe melted metals into a veſſel filled with vital air, than would have been produced in the ſame time in the open air. All theſe facts, and many others, which will be found in the particular hiſtory of each metal, are well calculated to prove, that a metallic oxyd is merely a chemical combination of metal and oxygen; that calcination is ſimply the act in which this combination takes place; and that the air of the atmoſphere is decompoſed during the proceſs.

The reduction of metallic oxyds, by the addition of combuſtible matters, likewiſe elucidates, and greatly tends to confirm, this theory. When an oxyd is to be reduced to the metallic ſtate, it is often neceſſary to heat it in cloſe veſſels, with ſome combuſtible matter, as greaſe, oil, charcoal, &c. In all theſe caſes the metallic oxyd is decompoſed, by depriving it of the oxygen which produced the calciform ſtate. This operation may be explained, by obſerving, 1. That metals are not the moſt combuſtible ſubſtances in nature, or, which is the ſame thing, their affinity with oxygen is not the greateſt poſſible. 2. That combuſtible animal, or vegetable ſubſtances, have a ſtronger affinity with oxygen than metallic ſubſtances have. 3. That, conſequently, when a metallic oxyd is reduced by the addition of charcoal, the latter being more combuſtible than the metal, or having a ſtronger affinity with oxygen, ſeizes it, and decompoſes the metallic oxyd, which conſequently paſſes to the metallic ſtate. Theſe operations, therefore, do not ſucceed well but in cloſed veſſels, becauſe the combuſtible matter, being excluded from the contact of air, can only burn by the aſſiſtance of that of the oxygen of the oxyd, Hence, alſo, the portion of the pure carbon which ſeizes the oxygen of the metallic oxyd, is found to be converted into carbonic acid after the reduction. While we are explaining the hiſtory of metallic calcination according to the modern theory, we muſt not forget to mention the doctrine of Stahl, which was almoſt univerſally adopted till the time of the lateſt diſcoveries reſpecting air and combuſtion. Stahl conſidered metallic ſubſtances as compounds of peculiar earths and phlogiſton. Calcination, according to him, conſiſts in the diſengagement of phlogiſton; and the reduction reſtores to the metallic calces the principle they loſt during their calcination. This theory, we may obſerve, is abſolutely contrary to that of the moderns, as it holds metals to be compound ſubſtances, while the pneumatic theory conſiders them as ſimple. According to Stahl, they loſe a principle in their calcination; and the modern doctrine proves, that during this operation they combine with a new ſubſtance. Laſtly, This great chemiſt imagined, that during reduction, the metallic calces reſumed the phlogiſton they had loſt by the action of fire; and the moderns, on the contrary, have proved, that reduction is nothing more than the ſeparation of the oxygen which combined with them during calcination.

After this ſlight compariſon of the two theories, let us endeavour to aſcertain which is ſupported by the greateſt number of facts. Stahl is entirely taken up in attempting to prove the exiſtence of phlogiſton in metals, but ſeems to have forgotten the influence of air in calcination: nevertheleſs, Beccher, John Rey, Boyle, and ſeveral other chemiſts, ſuſpected, before him, that the principal circumſtance depended upon that element. The theory of Stahl, however ſatisfactory it may have appeared before the time of the modern diſcoveries concerning air, could not therefore agree with all the facts which demonſtrate the neceſſity and action of that fluid in calcination. And we accordingly obſerve many phenomena not explicable, by that theory, and even contradictory to it. Such, for example, is the increaſed weight of metallic oxyds, beyond that of the metals before their calcination. We can never form any conception, how a body can become heavier by loſing one of its conſtituent parts; and as weight is one of the properties by which the preſence of matter is proved, the ingenious explanation, given by Morveau, in his diſſertation on Phlogiſton, relative to this phenomenon, cannot be admitted as entirely ſatisfactory; more eſpecially ſince the exiſtence of air in metallic oxyds has been proved. From theſe facts it therefore appears, that the pneumatic theory has great advantages over that of Stahl. Yet Macquer, guided by that philoſophical caution, which cannot be too ſtrongly recommended to every cultivator of ſcience, has thought proper to connect the modern diſcoveries with the doctrine of phlogiſton, and was even of opinion that they tended to confirm that doctrine. According to this celebrated chemiſt, metals cannot loſe their phlogiſton, and become calcined, but in proportion as the pure air of the atmoſphere precipitates, and becomes united to them, diſengaging, at the ſame time, the light they contain; and, on the contrary, they are not reducible, until light, aſſiſted by heat, ſeparates the pure air, and takes its place: ſo that theſe two bodies are mutually precipitated by each other. But as no one has proved the identity of light, and that which Stahl called phlogiſton, nor the exiſtence of light in combuſtible bodies, the opinion of Macquer is purely an hypotheſis, which may be entirely paſſed over, and which it is no longer allowed to admit.

As it is clearly demonſtrated, at preſent, that metallic oxyds are compounds of metals and oxygen, it becomes an important ſubject of inquiry, to aſcertain the various elective attractions, which exiſt between this principle and metallic ſubſtances. Lavoiſier has already made ſome progreſs in this intereſting reſearch; but experiments have not yet been ſufficiently multiplied, and the accuracy of their reſult is not well enough aſcertained, to allow of our entering into the ſubject at full length.

Metallic ſubſtances are changed by expoſure to the air, their ſurface being tarniſhed, and ſome of them becoming covered with ruſt. Chemiſts now conſider ruſt as a metallic oxyd. We ſhall have frequent occaſion to re-conſider this ſubject, and to ſhow, that the vapour of water oxydates many metals, and that the carbonic acid of the atmoſphere unites with them after calcination.

Water diſſolves ſome metals, and has no action on others. In the vaporous form, it ſingularly favours the production of ruſt, in ſuch metals as are ſuſceptible of that modification. The recent diſcoveries of Lavoiſier have ſhown, that it oxydates with great facility ſuch metals as are moſt combuſtible, as for example, zink and iron; and that it is itſelf decompoſed into oxygen, which unites to the metals and hydrogen which is diſengaged, in combination with a great quantity of caloric, and conſequently under the form of a very light gas.

Earthy matters do not appear to act on metallic ſubſtances; but they unite, by fuſion, with their oxyds.

The action of the ſalino-terreſtrial ſubſtances on the metals, is not known.

Alkalis diſſolve certain metals, though they act but feebly on moſt of them. The water which is always united to alkalis, appears to contribute greatly to the oxydation they produce in many metals.

Acids act ſtrongly on metals, and diſſolve them with various degrees of facility. The ſulphuric acid produces either hydrogen gas, or ſulphureous gas, accordingly as it is united to water, or concentrated. In the firſt caſe, the water is decompoſed, and affording its oxygenous principle to the metal, produces hydrogen gas: In the ſecond, the acid itſelf is decompoſed; and its oxygenous principle becoming partly fixed in the metallic ſubſtances, leaves the ſulphur ſtill united with a portion of that principle, and conſequently in the ſtate of ſulphureous gas. The ſulphuric acid, ſaturated with metallic oxyds, in either circumſtance forms ſulphats, formerly termed vitriols, which, when cryſtallized, muſt be conſidered as compounds of four bodies; namely, metal, oxygen, ſulphuric acid, and water. Theſe metallic ſulphats are variouſly coloured, cryſtallizable, ſoluble in water, decompoſable by heat, by vital air, whoſe oxygen they abſorb, by alkalis, which ſeparate the metallic oxyds, &c.

The nitric acid appears to act on metals with more rapidity than the ſulphuric, though it in general adheres to them much more ſlightly. A large quantity of nitrous gas is diſengaged during its action on theſe ſubſtances; the metal is more or leſs oxydated, and either falls down, or remains united to the acid. Stahl attributed this effect to the diſengagement of the phlogiſton of metals. The modern chemiſts, at preſent, think it is produced by the decompoſition of the nitric acid, and the ſeparation of a portion of the oxygen with the azot, which they conſider as the two principles of this acid. Nitric metallic ſolutions, or metallic nitrats, are more or leſs cryſtallizable and decompoſable by heat, by air, and by water. Alkalis ſeparate the metallic oxyds. The nitric, as well as the ſulphuric acid, has various degrees of attraction for the different metals. Prouſt has diſcovered, that ſeveral metallic ſubſtances take fire by the contact of this acid.

The muriatic acid, in general, acts with very little energy on metals. The water with which it is united, oxydates them, and diſengages hydrogen gas. The muriatic ſolutions of metals, are in general more permanent, and more difficultly decompoſed by heat, than thoſe which are made in the ſulphuric or nitric acids. Some afford cryſtals by heat; but in general they do not cryſtallize without difficulty. The muriatic acid has a ſtronger affinity, than the ſulphuric or nitric, with ſeveral metallic ſubſtances, and decompoſes ſolutions in the ſulphuric and nitric acids. The metallic muriats, or combinations of metals with the marine acid, are many of them volatile.

The oxygenated muriatic acid, oxydates moſt metals with the greateſt facility, by means of the exceſs of the oxygen it contains, and which is not ſtrongly united with it. It diſſolves them without effervеſcence, in the ſame manner as water diſſolves ſalt.

The carbonic acid acts weakly on metals, though it is capable of combining with moſt of them, as Bergman has ſhown. Combinations of metals with this acid are often found in nature; they are ſometimes cryſtallized, and are known by the name of ſpathoſe ores, of which iron and lead are inſtances, but we ſhall deſignate them like the other ſalts formed by this acid, by the names of carbonats of iron, lead, &c.

The fluoric and boracic acids, likewiſe unite with metals but the compounds they form are little known.

Among the various combinations of metals with acids, ſome are capable of cryſtallizing, while others aſſume no regular form. Some are decompoſed by fire, and others, on the contrary, are not at all changed by that agent. The greater number are changed from expoſure to air by abſorbing its oxygen. All are more or leſs ſoluble in water, and may be, for the moſt part, decompoſed by that fluid, as Macquer obſerved. All are precipitated by alumine, barytes, magneſia, lime, and alkalis, which have a ſtronger affinity with acids.

When certain metals, which have a ſtronger affinity with acids than others, are uſed to ſeparate the latter from their acid ſolutions, the precipitated metals re-appear with the metallic form and brilliancy, becauſe the oxygen, which was united to them in their ſtate of ſolution, is ſeparated, and becomes combined with the precipitant, which becomes diſſolved in the acid in its turn. For this reaſon, Lavoiſier conſiders the precipitations of metals by each other, as effects of their ſeveral affinities with the oxygenous principle.

Neutral ſalts are very little changed by the action of metals in the humid way; but if a mixture of theſe ſalts with metals be ſtrongly heated, many of them are decompoſed. Several ſulphuric ſalts form ſulphur in theſe circumſtances. Monnet is the only chemiſt who has mentioned this decompoſition with antimony. In a ſeries of experiments relative to this inquiry, I have diſcovered ſeveral other metals, ſuch as iron, zink, &c. which decompoſe ſulphat of potaſh, &c.

Nitre detonates with moſt metallic ſubſtances, and oxydates them more or leſs. This phenomenon depends on the greater affinity of oxygen with many of theſe ſubſtances, than it has with azot. Metals oxydated by this ſalt, are called metallic oxyds by nitre. The alkaline baſe of this ſalt often diſſolves part of theſe metallic oxyds.

Muriat of ammoniac is decompoſed by many metals, and by the oxyds of moſt metallic ſubſtances. Bucquet, who made many experiments relative to this ſubject, has obſerved, that all metals, on which the muriatic acid is capable of acting immediately, are capable of completely decompoſing muriat of ammoniac; that hydrogen gas is diſengaged during theſe decompoſitions; and that they do not take place in the ſame manner, with ſuch metals as are not ſoluble in the ordinary [illegible] muriatic acid. The ammoniac, obtained by theſe decompoſitions, is always very cauſtic and pure.

Almoſt all mineral combuſtible bodies unite eaſily with metals. Hydrogen gas gives them a deeper colour, and reduces ſome of their oxyds, becauſe it has a ſtronger affinity with oxygen, as is proved by ſeveral very ingenious experiments of Dr. Prieſtley. Theſe reductions of metallic oxyds by hydrogen gas, are accompanied with the production of a certain quantity of water, formed by the combination of this gas with the oxygen diſengaged from the oxyd.

Sulphur unites with moſt metals; its combinations form a kind of artificial ores; when they are moiſtened, or expoſed to a moiſt air, they become gradually *vitriolized*, or are gradually changed into metallic ſulphats. The alkaline ſulphures diſſolve all the metals. Sulphurated hydrogen gas colours them, and decompoſes their oxyds, which it cauſes to reſume the metallic ſtate, by abſorbing the oxygen they were united to.

Metals combine with each other with various degrees of facility, and produce alloys, whoſe reſpective properties render them very uſeful in the arts.

§ VI. *Methodical Arrangement of Metallic Subſtances.*

The number of metallic ſubſtances being conſiderable, renders it neceſſary to eſtabliſh an arrangement, or order of claſſing them, by which ſuch as have ſimilar properties may be placed together, and ſuch as differ may be ſeparated. Ductility is a leading character. Metallic ſubſtances, which are not at all ductile, or at leaſt which poſſeſs but a very inconſiderable degree of ductility, are called *ſemi-metals*. Thoſe, on the contrary, which are very ductile, are called *metals*. The ſemi-metals are either very brittle under the hammer, or capable of a ſmall degree of extenſion, which affords another ſub-diviſion of theſe ſubſtances. The metals may likewiſe be ſubdivided, with reſpect to the action of fire upon them. In fact, ſome, when treated with the contact of air, become quickly oxydated; others, on the contrary, treated in the ſame manner, experience no change. The firſt are the *imperfect*, and the latter the *perfect*, metals. But as the names of ſemi-metals and of imperfect metals are evidently derived from the falſe notions of the alchemiſts with regard to theſe ſubſtances, we ſhall adopt a different ſubdiviſion founded on the ductility of metals and their affinity for oxygen; we divide the 17 known metals into five ſections; we have not inſerted the uranium nor ſome of the other metallic ſubſtances recently announced, as their diſcovery is not yet fully eſtabliſhed.

Metallic Subſtances are either

SECT. I.
Brittle and acidifiable.
Arſenic,
Tungſten,
Molybdena.

SECT. II.
Brittle and non-acidifiable.
Cobalt,
Biſmuth,
Antimony,
Nickel,
Manganeſe.

SECT. III.
Semi-ductile and oxydifiable.
Zink,
Mercury.

SECT. IV.
Eaſily ductile and eaſily oxydated.
Lead,
Tin,
Iron,
Copper.

SECT. V.
Very ductile, and not eaſily oxydated.
Silver,
Gold,
Platina.

NOTES ON CHAPTER V.

[Page 170.]

[a] See *Reaumur Mem. de l'Acad. Roy, pour l'Ann.* 1724, p. 307. *Mongez Journ. de Phyſ.* 1780, p. 766. *Bergman Opuſc.* Vol. II. p. 16.

[b] See *Jean Rey, Eſſais ſur la recherche de la cauſe par laquelle l'etain et le plomb augmentent de poids quand on les calcine, à Bazas,* 1636. *Boyle's Works,* new experiments to make fire and flame ſtable and ponderable. *Mayow Oper. Hagæ-Comitum,* 1681, p. 25. *Becher Phyſica Subterranea. Bayen, Roſier's Obſervat. et Mem.* T. III. p. 120, 280, T. VI. p. 487. T. VII. p. 390. *Lavoiſier, Mem. de l'Acad.* 1774, p. 351. 1775, p. 520. 1782, p. 541.

[c] See *Berthollet ſur la combination des oxides metalliques avec les alkalis et la chaux, Ann. de Chem.* Tom. I. p. 52. *Fourcroy, Mem. de l'Acad. Roy.* 1790,

d For a farther account of the ſolution of metals in acids, ſee *Monnet Traite ſur la diſſolution des metaux. Bergman de præcipitatis metallicis*, Vol. II. p. 349. *Lavoiſier ſur la diſſolution du mercure dan l'acide vitriolique, Mem. de l'Acad.* 1777, p. 324. *Conſiderations generales ſur la diſſolution des metaux dans les acides, Mem. de l'Acad.* 1782, p. 492 et p. 512.

e We have had already (in page 190 of Volume I.) occaſion to mention the emiſſion of light which takes place during the combination of ſulphur with metallic bodies. This remarkable phenomenon, firſt obſerved by Scheele, is deſcribed by him in his Eſſays on Air and Fire. It has been very differently accounted for by chemical philoſophers. Deiman, Paets, Van Trootzwick, &c. who have made many experiments on this ſubject, conſider it as a proof of the occurrence of inflammation without the preſence or agency of oxygen, and deduce from it concluſions hoſtile to the French theory of combuſtion. Some doubts having ariſen with regard to the accuracy of theſe experiments, ſeveral chemiſts have been induced to repeat them, but the reſults which they have obtained tend rather to confirm than to diminiſh the doubts which prevail. This experiment has never been obſerved to ſucceed under water, and it has often failed in the hands of the beſt practical chemiſts, though tried in all the circumſtances which are conceived to be neceſſary to enſure ſucceſs. It has been alſo ſuggeſted by Richter, that the flowers of ſulphur contain water in a concrete ſtate; and that during the inflammation of the mixture the water is decompoſed. This ſuppoſition ſeems to receive ſome ſupport from the late experiments of Trommſdorff, who found that the water employed to waſh the mixture after inflammation gave a red colour to tincture of turnſole. Vapours appear to be diſengaged, and changes produced in the metallic mixture during its inflammation, which have not hitherto been examined with ſufficient accuracy. *Deiman, Paets, &c. Crell's Ann.* B. II. ſ. 383, 398. *Richter Uber die neuern Gegenſtande, Stuck*, I. ſ. 106. *Trommſdorff Journ. de Phyſ.* II. 1794, p. 273. *Scherer Nachträge*, ſ. 590.

CHAPTER VI.

CONCERNING ARSENIC, AND THE ARSENIC ACID *.

ARSENIC may be properly placed the firſt in the arrangement of ſemi-metals, becauſe it greatly reſembles ſalts. Kunckel conſidered it as a coagulated aqua-fortis ; Beccher and Stahl reckoned it a ſaline matter : Scheele has proved, that it is capable of forming a peculiar acid ; and, on the other hand, Brandt and Macquer have proved, that it is a true ſemi-metal. Arſenic, when poſſeſſed of all its properties, has the characters of metallic ſubſtances ; it is perfectly opake, ponderous, and brilliant.

Arſenic is often found native, in black heavy maſſes, ſcarcely brilliant. It has ſometimes the metallic luſtre, and reflects the colours of the rainbow ; in its fracture, it appears to be more brilliant than at its ſurface, and ſeems compoſed of a great number of ſmall ſcales ; when theſe ſcales appear externally, the ſpecimens are called *teſtaceous arſenic*, or, improperly, *teſtaceous cobalt ;* becauſe formerly, when the metallic character of arſenic was unknown, the teſtaceous arſenic was conſidered as an ore of cobalt, to which appellation the arſenical nature of moſt cobalt ores contributed.

Native arſenic is very eaſily known, when it has the metallic brilliancy and ſcaly texture ; but when it is black, and of a cloſe-grained texture, it is only diſtinguiſhed by its great weight, and total diſſipation on hot coals, in white fumes of a garlic ſmell. This laſt is abundantly found mixed with grey ſilver ore at St. Marie-aux-Mines, and is likewiſe found among the cobaltic ores of Saxony, and at Andrarum, in the province of Schonen in Sweden.

Arſenic is ſometimes naturally found in the form of a white oxyd, of a vitreous appearance, though more commonly in the form of flowers, or mixed with certain earths. This oxyd is alſo found at St. Marie-aux-Mines, and is known by the white fumes, and ſmell of garlic, which it exhales when thrown into the fire.

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* We give the name of arſenic, to the ſemi-metallic ſubſtance uſually called regulus of arſenic ; the latter denomination ought to be abandoned as improper. The ſubſtance called white arſenic, is an oxyd of the ſemi-metal.

The oxyd of arſenic is often combined with ſulphur, and then forms *orpiment* and *realgar*, or the ſulphurated yellow and red oxyds of arſenic. Native orpiment is found in yellow, brilliant, and as it were, talcky maſſes, often mixed with realgar, and ſometimes of a greeniſh colour. Realgar is of a red colour, more or leſs lively and tranſparent, and often cryſtallized in brilliant needles. It is found in great quantities at Quito, and near Mount Veſuvius. Theſe two ſubſtances appear to differ only in the degree of fire, by which they have been combined.

Miſpikel, or arſenical pyrites, is the laſt ore of arſenic, and contains that ſemi-metal combined with iron. Miſpikel is ſometimes cryſtallized in cubes, and is frequently without any regular form. Wallerius calls it white cubic ore of arſenic.

Arſenic is likewiſe found in the ores of cobalt, antimony, tin, iron, copper, and ſilver.

Pure arſenic, likewiſe called *regulus of arſenic*, is of a blackiſh grey, reflecting the colours of the rainbow. It is very ponderous and friable. Expoſed to heat in cloſe veſſels, it ſublimes without decompoſition, being one of the moſt volatile among metallic ſubſtances[a]. When ſlowly ſublimed, it cryſtallizes into regular tetrahedral figures. Arſenic, heated with contact of air, becomes very quickly oxydated, and its oxyds are diſſipated in the form of white fumes, with a very ſtrong ſmell of garlic. The red ore of arſenic burns with a very perceptible flame, of a blueiſh colour. In this combuſtion, it combines with the baſe of vital air, and forms the compound, known by the name of *white arſenic*, or *calx of arſenic*; and by this proceſs it is, that the arſenical ores of cobalt afford a large quantity of white fumes when in the furnace, which are condenſed in the chimney, in the form of a white, ſtratified, ponderous, ſemi-vitrified matter, known in commerce by the name of *arſenic*. This is a true vitreous oxyd of arſenic.

Oxyd of arſenic differs eſſentially from all other metallic oxyds. Its taſte is very ſtrong, and even cauſtic; and it is one of the moſt violent of poiſons. Expoſed to heat in cloſe veſſels, it riſes in the form of a white cryſtallized powder, called *flowers of arſenic*[b]; if the heat be very ſtrong, a very tranſparent glaſs is produced, capable of cryſtallizing, in the form of a tetrahedral ſolid, with truncated angles. This glaſs quickly tarniſhes in the air. None of the metallic oxyds, excepting that of arſenic, is volatile without addition. It is alſo very fuſible, and vitrifiable. Beccher attributed the weight and volatility of arſenic to a peculiar principle, which he called *mercurial*, or *arſenical earth*, the exiſtence of which Stahl was unable to prove.

Arſenic, in the metallic ſtate, does not act ſenſibly on combuſtible bodies; but the oxyd of arſenic evidently alters them, and at the ſame time reſumes the metallic ſtate. Stahl thought, that the phlogiſton loſt by the arſenic in *calcination*, is reſtored by the combuſtible body. The moderns, on the contrary, have proved that the oxyd of arſenic is a compound of arſenic and oxygen; and that the combuſtible body, by depriving it of this principle, cauſes the arſenic to reſume the metallic ſtate. To reduce the oxyd of this ſemi-metal, it is pulverized, and made into a paſte with ſoft ſoap, which is put into a matraſs on a ſand bath. A gentle heat is firſt given, to dry the oil; and when humid vapours are no longer exhaled, the fire is raiſed to ſublime the arſenic. The matraſs being broken, is found to contain, in its upper part, a maſs, poſſeſſing the metallic brilliancy. Moſt of the coal of the oil remains at the bottom of the matraſs[c].

Arſenic, expoſed to the air, becomes ſenſibly black. The vitrified oxyd of arſenic loſes its tranſparency, and aſſumes a milky colour by a kind of efloreſcence.

Arſenic does not appear to be attacked by water, but its oxyds are ſoluble in this menſtruum, in a quantity ſomewhat greater when heated than when cold; the ſolubility of this ſubſtance likewiſe varies, accordingly as it has been more or leſs perfectly oxydated[d]. The oxyd of arſenic, by ſlowly evaporating its ſolution, affords yellowiſh cryſtals, in triangular pyramids. No metallic ſubſtance we are acquainted with, is ſo largely ſoluble in water: in this property, and alſo in its ſtrong taſte, it reſembles ſaline ſubſtances[e].

Oxyd of arſenic unites with earths by fuſion, becoming fixed with them, and accelerating their vitrifications; but all the glaſſes, into which arſenic enters, have the bad quality of becoming tarniſhed, by the action of the air, in a ſhort time. The action of the ſalino-terreſtrial matters on arſenic, or its oxyd, is not known [f]. Cauſtic fixed alkalis, which have no ſenſible action on arſenic, diſſolve its oxyd very well. Macquer, in his valuable Memoirs on this ſubject, publiſhed among thoſe of the Academy for the year 1746, has obſerved, that when the oxyd of arſenic, in powder, is boiled in a ſolution of fixed nitre, or of cauſtic potaſh, it is diſſolved completely, and forms a brown gelatinous fluid, whoſe conſiſtence gradually increaſes. This compound, to which he gives the name of *liver of arſenic*, does not cryſtallize, but becomes hard and brittle; it is deliqueſcent and ſoluble in water, which produces ſome brown flakes. When urged by a ſtrong fire, the arſenic is diſſipated. It is decompoſed by acids. Soda exhibits the ſame phenomena; but its ſolution afforded Macquer irregular cryſtals, whoſe general form he found it impoſſible to deſcribe [g].

The ſulphuric acid, even when concentrated, does not attack arſenic in the cold; but if it be boiled with this ſemimetal in a retort, much ſulphureous gas comes over, which is ſucceeded by a ſmall portion of ſulphur, and the arſenic is found converted into an oxyd, but not diſſolved. Concentrated and boiling ſulphuric acid likewiſe diſſolves the oxyd of arſenic, but it ſeparates in cooling, in the form of a precipitate. In this combination, it acquires a conſiderable fixity; but Bucquet affirms, that it reſumes all its qualities when the acid is waſhed off by water [h].

The nitric acid, applied to arſenic, ſtrongly attacks and oxydates it; it likewiſe diſſolves a conſiderable quantity of the oxyd by the aſſiſtance of a mild heat. Saturated with either of theſe ſubſtances, it preſerves its own peculiar ſmell; when ſtrongly evaporated, it forms a ſalt, which, according to Bucquet, has not a regular form, but is by Baumé affirmed to be partly cubical, and partly ſhaped to a point, like diamonds. Wallerius affirms, that its cryſtals reſemble nitrat of ſilver. Nitrat of arſenic ſtrongly attracts the humidity of the air; does not detonate on hot coals; is decompoſed neither by water nor by acids ; and affords no precipitate on the addition of alkalis. The latter nevertheleſs decompoſe it, according to Bucquet ; ſince nitre and arſeniat of potaſh are obtained by evaporating the nitrous arſenical ſolution, with the previous addition of alkaline lixivium. We ſhall preſently ſee, that all chemiſts were for a time embarraſſed with the ſingular nature of the ſolutions of arſenic, and its oxyd, in acids, and attempted in vain to diſcover what happens in the combination of this oxyd with the nitric acid, as they did not ſuſpect that the arſenical acid is produced. We ſhall only remark, in this place, that the oxyd of arſenic deprives the nitric acid of great part of its oxygen [k].

The muriatic acid, aſſiſted by heat, diſſolves arſenic and its oxyds, according to Bucquet. Theſe combinations may be precipitated by fixed or volatile alkalis. Baumé affirms, that this metal diſſolves in boiling muriatic acid, and that a yellow powder, reſembling ſulphur, is precipitated [l]. Bayen and Chalard, in their Inquiries reſpecting Tin, have aſcertained, that the muriatic acid does not act on arſenic in the cold, and ſcarcely at all when heated. When this metal, in powder, is thrown into oxygenated muriatic acid gas, it burns with a white flame [m].

The action of other acids on arſenic and its oxyd are not known. This ſemi-metal, mixed with nitre, and thrown into a red hot crucible, produces a ſtrong detonation. The nitric acid calcines and burns the ſemi-metal ; and after the operation, the crucible is found to contain the fixed alkaline baſe of the nitre and the arſenic, in the form of an oxyd, and partly combined with the alkali [n].

If equal parts of oxyd of arſenic and nitre be mixed together, and expoſed to diſtillation in a retort, very red vapours of ſpirit of nitre come over. This acid cannot be condenſed, but by a ſmall quantity of water put into the receiver, which gives it a blue colour. Beccher, Stahl, and Kunckel, have deſcribed this operation. Macquer, who carefully repeated it, having examined the reſidue, to which theſe chemiſts did not attend, diſcovered that it was a peculiar neutral ſalt, which he called *neutral arſenical ſalt.* It ought to be termed arſeniat of potaſh. This ſalt diſſolved in water, and evaporated in the open air, affords very regular cryſtals in tetrahedral priſms, terminated by pyramids of four equal ſides; the form of theſe cryſtals, however, ſometimes varies.

Arſeniat of potaſh, expoſed to heat, melts readily, and remains in fuſion, without becoming alkalized, or any part of the arſenic being driven off. It is not ſenſibly altered by the action of air. It is much more ſoluble in water than pure oxyd of arſenic, and diſſolves more plentifully in hot than in cold water [o].

It is not decompoſable by any pure acid, but its component parts may be ſeparated by the way of double affinity. If a ſolution of ſulphat of iron or *martial vitriol* be added in a ſmall quantity to a ſolution of this ſalt, a double decompoſition takes place. The ſulphuric acid quits the iron to unite with the alkali, and the arſenic acid unites with the oxyd of iron. Combuſtible matters readily decompoſe the arſeniat of potaſh.

Oxyd of arſenic likewiſe decompoſes nitrat of ſoda by diſtillation, and forms with its baſe arſeniat of ſoda; which, according to Macquer, does not greatly differ from the ſalt laſt ſpoken of, and cryſtallizes abſolutely in the ſame manner [p]. This oxyd produces the ſame effect with ammoniacal nitrat, conſtituting an arſeniat of ammoniac with its baſe [q]. It was formerly thought that this operation required to be conducted with great precaution, on account of the property which nitrat of ammoniac has of detonating, without addition, in cloſe veſſels: but Pelletier has proved, that it may be made without danger even in the quantity of ſeveral pounds. The diſcovery of the arſenical neutral ſalt of Macquer was a prelude to the diſcovery of the arſenical acid, that illuſtrious chemiſt having ſeen and obſerved that the oxyd of arſenic acts as an acid in this ſalt. But it is to Scheele, as we ſhall preſently obſerve, that we are indebted for an accurate knowledge of theſe new combinations.

Oxyd of arſenic is not decompoſed by alkaline muriats, and does not ſeparate the ammoniac from ammoniacal muriat, but with great difficulty; in which property it agrees with the arſenic [r].

The action of combuſtible mineral matters on arſenic has not been examined. The oxyd ſeems reducible by hydrogen gas, which has a ſtronger affinity than arſenic with oxygen or baſe of vital air [*].

Oxyd of arſenic combines very well with ſulphur. When theſe two ſubſtances are melted together, a yellow or red volatile body is produced, which has a weaker taſte than pure oxyd of arſenic, and is not ſoluble in water. This yellow ſulphurated oxyd of arſenic is called *factitious orpiment*, and is capable of cryſtallizing in tetrahedrons, like the vitreous oxyd of arſenic; when red it is called *realgal*, *realgar*, *factitious rizigal*, or *red arſenic*. We call this compound red ſulphurated oxyd of arſenic [t]. Some chemiſts have thought that the realgal does not differ from orpiment, but in the larger proportion of ſulphur it is ſuppoſed to contain: but Bucquet has proved, that the compound of ſulphur and oxyd of arſenic is red, when it has been melted; nothing more being neceſſary than to expoſe orpiment to a ſtrong heat, in order to convert it into realgar. I find that realgar is much leſs volatile than orpiment, ſince it remains at the bottom of the matraſs in which the mixture of oxyd of arſenic and ſulphur has been ſublimed, where it has the form of porous red laminæ, which have been manifeſtly fuſed. The artificial orpiment and realgar do not differ from the natural: they are decompoſed by lime and alkalis, which have a ſtronger affinity with ſulphur than the oxyd of arſenic has. This oxyd, nevertheleſs has, like acids, the property of decompoſing alkaline ſulphures.

All the properties of the oxyd of arſenic prove that this metallic and combuſtible ſubſtance, united to the baſe of vital air, aſſumes the characters of a ſaline ſubſtance. The theory we have explained in treating of ſalts in general, appears, therefore, to be confirmed by theſe experiments. Macquer, as I have already obſerved, took notice in the courſe of his valuable diſcoveries reſpecting the arſeniat of potaſh, that the oxyd of arſenic performs the part of an acid in this ſalt. But it was difficult to conceive why the oxyd of arſenic immediately diſſolved in potaſh ſhould differ ſo greatly from the ſame combination made by the decompoſition of nitre by the ſame oxyd. Scheele, reaſoning from the diſcovery of the oxygenated muriatic acid, imagined that the ſame thing happens when nitre is diſtilled with oxyd of arſenic. He thinks that the nitric acid ſeizes the phlogiſton ſtill remaining in the oxyd, and that the oxyd, when deprived of this laſt portion, becomes converted into a peculiar acid, which we call arſenic acid. He prepared the arſenical acid by proceſſes ſimilar to thoſe uſed in obtaining the oxygenated muriatic acid. One of theſe conſiſts in diſtilling a mixture of oxygenated muriatic acid and oxyd of arſenic. The muriatic acid, according to him, ſeizes the phlogiſton of the oxyd, which then paſſes to the acid ſtate. The arſenical acid is likewiſe prepared by diſtilling ſix parts of nitric acid from one of the oxyd. Much nitrous gas is produced, and the oxyd of arſenic aſſumes the characters of an acid; it muſt be expoſed for a conſiderable time to heat, in order to diſengage all the ſuperabundant nitrous acid[u]. The facts here related are greatly in favour of the modern doctrine. On the one hand, it is difficult, according to Stahl, to ſhow that oxyd of arſenic contains phlogiſton; and on the other, nothing is more eaſily conceived, according to the new theory, than the tranſition of this oxyd to the acid ſtate, by the action of ſpirit of nitre, or oxygenated muriatic acid. The oxyd of arſenic appears to have a ſtrong affinity with the oxygen, with which it is not ſaturated; when it is diſtilled with the nitric, or with the oxygenated muriatic acid, it ſeizes the oxygen contained in either. The more of this principle it contains, the nearer it approaches to the nature of ſaline ſubſtances; and when it is entirely ſaturated, it aſſumes all the characters of acids, which, as we have proved, are combuſtible ſubſtances combined with oxygen, to which they owe their ſaline properties. This theory very happily explains why the oxyd of arſenic not ſaturated with oxygen, but in the ſtate of ſimple oxydation by fire, does not form the arſeniat of potaſh; and why it cannot conſtitute that ſalt till it has been previouſly treated with acids, from which, by the aſſiſtance of heat, it takes the oxygen[x].

The arſenical acid differs greatly from the common oxyd of arſenic. Its taſte is ſtronger; it is fixed in the fire; ſo that the difference with reſpect to volatility affords a method of accurately ſeparating from this acid the portion of oxyd of arſenic it may contain. Its fixity, when treated with the ſulphuric acid, is doubtleſs a conſequence of its approach to the acid ſtate. It is capable of being converted into a tranſparent glaſs by fuſion; in which melted ſtate, it acts as a flux on earthy ſubſtances, and appears to be capable even of corroding glaſs. It ſlightly reddens blue vegetable colours. I have obſerved, that by expoſure to air, it loſes its tranſparency, and ſcales off in fragments, which are often pentagonal, and gradually attract humidity. It is ſoluble in two parts of water, and readily combines with lime, but more difficultly with barytes and magneſia. When united with alkalis, it forms neutral ſalts, decompoſable by lime, according to Bergman. Barytes and magneſia appear likewiſe to have a ſtronger affinity with this acid than alkalis, according to the ſame chemiſt. Many experiments remain yet to be made for the diſcovering of all the properties of the arſenical acid. Pelletier has prepared this acid, by decompoſing ammoniacal nitrat by oxyd of arſenic; the ammoniacal arſeniat which is produced gives out its volatile alkali by heat; and by the continued action of fire, the arſenical acid will remain pure and diſengaged at the bottom of the retort [y].

Bergman obſerves, that the ſpecific gravity of arſenic varies greatly from its metallic to its acid ſtate. The following are given by him: Regulus of arſenic, 8,308; vitreous oxyd of arſenic, 5,000; white oxyd of arſenic, 3,706; arſenical acid, 3,391 [z].

Arſenic is uſed in ſeveral arts, more eſpecially in dying. The arſeniat of potaſh is likewiſe uſed; and Baumé has long prepared it for manufactories. The facility with which the oxyd of arſenic diſſolves in water, and in all aqueous fluids, renders it the more dangerous, as it is highly poiſonous, and may be very eaſily conveyed in ſuch fluids. The following ſymptoms denote that a perſon has been poiſoned with arſenic: The mouth is dry, the teeth ſet on edge, and the throat contracted; the patient ſpits involuntarily, has a ſtrong ſenſe of pain at the ſtomach, great thirſt, ſickneſs, vomiting of mucous and bloody matter, excruciating cholics, cold ſweats, convulſions, and, ſoon after, death. An examination of the ſuſpected food will ſoon ſhow whether it contains the poiſon of arſenic. If a portion be previouſly dried, and thrown on hot coals, a white fume ariſes of a garlic-like ſmell.

It was formerly uſual to give mucilaginous drinks, or milk, or mild oils, in large doſes, to perſons poiſoned by oxyd of arſenic, with the intention of relieving the viſcera, and carrying off the greater part of the arſenic. Navier, a phyſician of Chalons, who has made inquiries concerning the beſt remedies againſt the poiſon of arſenic, has diſcovered a ſubſtance which combines with it in the humid way, and deſtroys the greateſt part of its cauſticity. This ſubſtance is the calcareous or alkaline ſulphures, and is ſtill better adapted to the intention, when it holds a ſmall quantity of iron in ſolution. When this ſulphure is poured into a ſolution of oxyd of arſenic, it is decompoſed without emitting any ſmell; becauſe the oxyd of the arſenic combines with the ſulphur, and forms orpiment; and at the ſame time unites with the iron, if it contains any. Navier preſcribes a drachm of the *liver of ſulphur* in a pint of water, which he directs to be taken a glaſs at a time; or five or ſix grains of dry ſulphure of potaſh may be given in pills, a glaſs of warm water being taken after each pill. When the firſt ſymptoms are diſſipated, he adviſes the uſe of ſulphureous mineral waters; experience having ſhown him that they are very efficacious in removing the tremors and paralytic affections, which uſually remain after the oxyd of arſenic has been taken, and often bring on conſumptions, that terminate in death. Navier likewiſe approves the uſe of milk, becauſe it diſſolves oxyd of arſenic as well as water does; but he condemns the uſe of oils for the contrary reaſon.

NOTES ON CHAPTER VI

ARSENIC.

[a] This is ſaid to take place in a temperature of about 356° of Fahrenheit's thermometer.

[b] The heat neceſſary to produce this effect is ſaid to be not more than equal to 383° of Fahrenheit.

[c] In ſpite of every precaution which can be taken, the arſenic generally carries over along with it a portion of the oxyd. In order to obtain this metal, therefore, in a very pure ſtate, it becomes neceſſary to mix it with a freſh quantity of ſoap, and to ſubject it a ſecond, or even a third time, to the proceſs of ſublimation. Equal parts of a fixed oil, or black flux, ſerve equally well with ſoap for the reduction of oxyd of arſenic.

d The oxyd of arſenic is ſoluble, according to Bergman, in about 80 times its weight of water at the temperature of 60° of Fahrenheit, or in 15 times its weight of boiling water. The aqueous ſolution of oxyd of arſenic gives a red colour to the tincture of litmus, and a green to the infuſion of violets. It produces no efferveſcence with the carbonats of earths and alkalis.

e Fixed oils diſſolve arſenic in a boiling heat, and form with it a dark coloured maſs, having the conſiſtence of an unguent. They unite ſtill more readily with the oxyd, which the eſſential oils alſo diſſolve.

f Lime and barytes unite, in the manner Fourcroy deſcribes, with oxyd of arſenic; but magneſia, alumine, and ſilex, in their pure ſtate, are ſaid to be incapable of combining with this ſubſtance. Theſe earths fuſe eaſily, however, with oxyd of arſenic, by the addition of a little lime or alkali.

g Oxyd of arſenic melts in the dry way with the fixed alkalis into a ſubſtance which remains fixed in the fire. Potaſh, according to Bergman, can unite in this way with two, and ſoda with three parts of the oxyd. Ammoniac diſſolves oxyd of arſenic by digeſtion. When diſtilled two or three times over this oxyd to dryneſs, it unites with the oxyd ſo ſtrongly, that the combination may be melted without being decompoſed. It is ſingular that acids produce no precipitation from the ſolution of oxyd of arſenic in ammoniac. Lime water diſſolves a ſmall portion of the oxyd of arſenic by boiling them together, but this portion is immediately precipitated by the addition of an acid.

h It is ſtill very doubtful whether this ſolution forms a true *ſulphat of arſenic.* When two parts of concentrated ſulphuric acid is repeatedly diſtilled with one of the oxyd of arſenic, the maſs remaining in the retort loſes its volatility, and aſſumes a cryſtalline appearance; becomes afterwards opake in the air, attracts humidity, and exhibits the properties of an acid liquor. The ſulphureous acid gas is produced by the loſs of oxygen, or, more properly ſpeaking, by its tranſition from the ſulphuric acid to the oxyd of arſenic. The cryſtalline maſs, therefore, is acid of arſenic, which may be again reduced to the ſtate of an oxyd, by expoſure to the flame of a blow pipe, or by heating it in contact with powder of charcoal.

k It may alſo be doubted whether the ſolution of oxyd of arſenic in nitric acid forms a *nitrat of arſenic.* Some of the properties mentioned by Fourcroy, ſuch as the arſenic not being precipitated by alkalis, ſeem to indicate that this ſolution ought to be conſidered as a mixture of acids, rather than a combination of the nitric acid with the oxyd of arſenic. When this ſolution alſo is expoſed to a high temperature, the nitric acid is diſſipated, and arſenic acid remains alone in the retort.

l This ſubſtance is extremely volatile, though but ſparingly ſoluble even in boiling water. It ſeems to be a muriat of arſenic, for alkalis precipitate from its ſolution the arſenic in the ſtate of an oxyd. It is decompoſed by heating it with charcoal. According to Wenzel this combination is not decompoſed by alumine. In the diſtillation of one part of oxyd of arſenic with three of muriat of ſoda, and one of burned ſulphat of iron, a thick tranſparent brown fluid paſſes over into the receiver, and with this a thinner yellow and tranſparent fluid, which ſinks to the bottom of the receiver. The thick fluid is termed *Butter*, and the thinner *Oil of Arſenic.* Theſe fluids ſeem to be combinations of the muriatic acid with oxyd of arſenic in different degrees of oxydation. The butter, in which the oxydation ſeems to be more complete, gives out ſuffocating vapours; when expoſed to the air, abſorbs moiſture, and is at laſt decompoſed. It lets fall a precipitate by the addition of water, which conſiſts chiefly of oxyd. Preſerved for ſome time in a cloſe veſſel, butter of arſenic cryſtallizes, and forms the very volatile ſalt, which is ſparingly ſoluble in boiling water. Muriatic acid diſſolves only a ſmall portion of this ſalt. If the acid be uſed in a diluted ſtate, it produces an immediate precipitation of the arſenic. The *oil* of arſenic ſeems to be a combination of the oxyd with the acid in a leſs concentrated ſtate, or a more diluted *butter of* arſenic. It unites with muriatic acid in all proportions, but the affuſion of water produces an immediate precipitation of the oxyd. Oil of arſenic effervеſces with carbonat of alkalis. By ſlow evaporation it affords cryſtals of muriat of arſenic, which in ſolution again bear a ſtrong reſemblance to oil of arſenic. A true butter of arſenic is produced by digeſting in cloſe veſſels oxyd of arſenic with oxygenated muriatic acid. If, to a ſolution of oxyd of arſenic in concentrated boiling muriatic acid be added three times the quantity of nitric acid, a conſiderable quantity of nitrous gas will be diſengaged. If the mixture be diſtilled to dryneſs, arſenic acid alone will remain in the retort. Oxyd of arſenic, by digeſtion and diſtillation with oxygenated muriatic acid, is converted into arſenic acid.

m Fluoric acid has no action on arſenic, but it unites with its oxyd, and forms a true *fluat of arſenic*. The properties of this ſalt, which exiſts in ſmall granular cryſtals, have been but little inveſtigated.

Boracic acid, in the moiſt way, has no action on arſenic, but it diſſolves the oxyd. The ſalt which is formed is ſoluble in water, and the ſolution depoſits by evaporation the *borat of arſenic*, partly in a pulverulent form, and partly in that of branched ſpiculæ.

Phoſphoric acid, which has no action on arſenic, diſſolves its oxyd completely. It forms, according to Bergman, a cryſtallized *phoſphat of arſenic*, which is difficultly ſoluble in water. This ſalt is decompoſed in the fire.

Tartaric acid unites by boiling it in water with oxyd of arſenic, and forms a cryſtallizable *tartrite of arſenic*, the properties of which have been but little inveſtigated.

Oxalic acid diſſolves oxyd of arſenic even without the aſſiſtance of heat, and forms with it an *oxalat of arſenic*, which is obtained in the form of priſmatic cryſtals by evaporation. This ſalt melts readily in the fire, and is decompoſed by ſublimation, the decompoſed acid riſes firſt, and afterwards the oxyd of arſenic. Oxalat of arſenic diſſolves eaſily in water, and in ſpirit of wine. It gives a red colour to tincture of litmus.

Acetic acid forms by digeſtion, or boiling with oxyd of arſenic an *acetat* of that metal, which exiſts in ſmall grains, and is ſparingly ſoluble in water. The combinations of the ſuccinic, citric, and malic acids with arſenic are not yet known.

Benzoic acid, according to Trommſdorff, diſſolves oxyd of arſenic, and forms with it a *benzoat of arſenic*. This ſalt, which ſhoots into fine radiated cryſtals, has an acid pungent taſte, effloreſces in the air, diſſolves readily in hot water, and cryſtallizes again by cooling.

Carbonic acid neither unites with arſenic nor its oxyd, for water impregnated with this acid diſſolves no more of the oxyd of arſenic than would be diſſolved by common water. The gallic acid produces no change in a ſolution of arſenic, ſo that the *gallat of arſenic* is ſtill unknown.

Pruſſic acid precipitates arſenic from its ſolution in nitro-muriatic acid. The precipitate is of a white colour, is ſoluble in a large quantity of water; and the ſolution, when evaporated to dryneſs, forms a ſemi-tranſparent maſs, which is probably Pruſſiat of potaſh.

The formic acid, according to Bergman, acts on oxyd of arſenic, and forms with it cryſtalline grains, which are difficult of ſolution in water.

As the ſolutions of arſenic in the different acids are to be conſidered as mixtures of acids rather than as neutral ſalts, it becomes difficult to aſcertain the degrees of affinity among acids for arſenic. Muriatic acid, and even the oxalic, have, according to Bergman, a ſtronger affinity for arſenic than the ſulphuric. The degrees of the other acids are ſtill very undetermined. *Gren's Handbuck Arſenik.*

n If equal parts of theſe two ſubſtances be uſed, the ſalt remaining will contain an exceſs of alkali, which renders it deliqueſcent and uncryſtallizable. By adding a ſmaller proportion of nitre, and by employing a lower degree of heat, a cryſtallizable arſeniat of potaſh will be obtained. A ſmall exceſs of arſenic acid is required for the production of this ſalt.

o Arſeniat of potaſh produces no change in the infuſion of violets, but it gives a red colour to the tincture of litmus.

p Arſeniat of ſoda does not redden the tincture of litmus, but it gives a green tinge to the infuſion of violets.

q This ſalt has no effect on the colour of litmus, but it gives a green tinge to the tincture of violets. If the cryſtals of arſeniat of ammoniac be expoſed to a briſk heat, they loſe their tranſparency, and a portion of the ammoniac is driven off. In this ſtate it gives a depoſit with acids. Combined with exceſs of acid, this ſalt ſhoots into long needle-ſhaped cryſtals, which deliqueſce in the air. Cauſtic ammoniac is evolved from it by diſtillation; but in this proceſs a portion of the ammoniac is decompoſed, while the arſenic acid is changed to the ſtate of an oxyd. Does not the hydrogen of the ammoniac unite with the oxygen of the arſenic to form water?

r Neither the ſulphats nor muriats of potaſh or ſoda ſuffer any change when treated in the ſame way with oxyd of arſenic. Diſtilled with acetat of potaſh, the oxyd of arſenic exhibits ſome curious phenomena, which have been deſcribed by Morveau, but which do not ſeem to have met with the inveſtigation they deſerve. The reſidue appears to be a carbonat of potaſh.

s Phoſphorus unites with arſenic, and forms with it a phoſphure of arſenic. If equal parts of theſe ſubſtances be melted together in a retort with a briſk fire, a black, ſhining, brittle maſs is formed, which effloreſces in the air, and is ſoluble in water. Phoſphorus decompoſes the oxyd of arſenic. If theſe ſubſtances be kept in contact under warm water, ſo that the melted phoſphorus may act on the oxyd of arſenic, a portion of the phoſphorus is converted into phoſphoric acid, and the arſenic now unites with the remaining portion of phoſphorus.

t When oxyd of arſenic is diſtilled with ſulphur, a quantity of ſulphureous acid gas is ſaid to be diſengaged. In giving a portion of its oxygen to the ſulphur, is the oxyd completely reduced; or does it ſtill retain ſome of this principle in combining with ſulphur to form realgar?

The yellow and red ſulphures of arſenic are neither ſoluble in water nor in ſpirit of wine. The nitric and nitro-muriatic acids ſeparate the arſenic by the aſſiſtance of heat from the ſulphur; but the firſt only partially, ſince it changes merely the red ſulphure to the yellow. The nitro-muriatic acid extracts all the arſenic from the yellow ſulphure, ſo as to leave the ſulphur behind in the form of a grey powder.

When cauſtic fixed alkali is boiled with ſulphure of arſenic, an alkaline ſulphure is formed, which holds the arſenic in ſolution; but the ſulphur and arſenic are both precipitated by the addition of an acid. Unſlaked lime boiled with the red or yellow ſulphure, forms a ſulphure of lime, which alſo holds the arſenic in ſolution. This is the ſolution which has been ſo commonly employed as a teſt of the purity of wines. Sulphure of arſenic becomes ſoluble in expreſſed oils by the aſſiſtance of heat.

If a ſolution of oxyd of arſenic be added to water impregnated with ſulphurated hydrogen gas, a precipitation of yellow ſulphure takes place. Does the hydrogen in this proceſs unite with the oxygen of the arſenic to form water?

The ſulphure of arſenic may be decompoſed by forming it into a paſte with an alkali diſſolved in water, and by expoſing this paſte in cloſe veſſels to a gradually increaſed fire. The arſenic ſublimes in the form of white flowers, and leaves behind it an alkaline ſulphure, which always contains a little arſenic. When too great a quantity of alkali is uſed, it fixes the arſenic.

u In Scheele's experiments, only a very ſmall quantity of acid of arſenic was formed by diſtilling the oxyd of this metal with nitric acid alone. His proceſs for obtaining arſenic acid is the following: Two ounces of oxyd of arſenic are to be diſſolved by a boiling heat in ſeven ounces of pure muriatic acid, contained in a tubulated retort; and while the ſolution is ſtill warm, three ounces and a half of pure nitric acid, together with the muriatic acid which may have paſſed over into the receiver, are to be added. The mixture will now begin to foam, and nitrous gas to be diſengaged. The diſtillation is to be continued till this gas ceaſes to come over, when an ounce of finely powdered oxyd is again to be added, and a gentle heat applied till it alſo be diſſolved. An ounce and a half of nitric acid is then to be added, and the whole diſtilled to dryneſs, taking care to increaſe the fire at laſt, ſo as to make the maſs red hot. On breaking the retort, *dry acid of arſenic* will be obtained. The acid may be obtained in the liquid ſtate, by diſſolving the dry acid, with the aſſiſtance of heat, in twice its own weight of water. See *Scheele's Eſſays*, p. 143.

x The oxyd of arſenic is ſaid to gain about 1-9th of its weight by being converted into an acid.

y Acid of arſenic, according to Scheele, is reduced by a violent heat to the ſtate of an oxyd. He was able to effect this reduction only partially in a retort, but completely in a crucible. Heated to redneſs with powder of charcoal, the mixture inflames with violence, and the whole of the acid is reduced. Spirit of wine diſſolves acid of arſenic; but the acid does not ſeem to undergo any change, either by digeſtion or by diſtillation, with that fluid. Sulphur has no action by digeſtion on arſenic acid; but, when diſtilled with it in a glaſs retort, ſulphureous acid gas is diſengaged, and the maſs riſes in the form of a red ſulphure. Sulphat of potaſh and ſoda are decompoſed in an intenſe heat by arſenic acid. The ſulphat of ſoda did not ſeem to Scheele to require ſo intenſe a heat for this purpoſe as that of the potaſh. See *Scheele, Crell's New Entdeck, Drit.* Th. ſ. 125.

Acetat of alumine is decompoſed by arſenic acid.

If arſenic acid be dropped into lime-water, a combination of this acid with the lime is produced, which is rendered ſoluble by an exceſs of acid. The ſolution affords by evaporation ſmall cryſtals of arſeniat of lime. This ſalt may likewiſe be formed by adding arſenic acid to the carbonat of lime. Arſeniat of lime is not decompoſed by the fire, but the addition of carbon cauſes the arſenic to ſublime in the form of a white oxyd. The carbonats of the alkalis produce, by double affinity, a decompoſition of this ſalt; not ſo the cauſtic alkalis. Lime-water ſeems to produce a decompoſition of the arſeniat of potaſh. Arſenic acid diſſolves magneſia. This combination forms, when accurately ſaturated, a ſalt difficult of ſolution in water, but which becomes ſoluble by exceſs of acid, and in that ſtate forms a gelatinous maſs by evaporation. If this difficultly ſoluble ſalt be diſſolved in acetic or nitric acids, and the mixture ſlowly evaporated, it ſhoots into beautiful radiated priſmatic cryſtals, which effloreſce in the heat, but which are not decompoſed by it. By the addition of carbon to this ſalt in the fire, the arſenic is diſſipated in the form of an oxyd. Whether cauſtic fixed alkalis and lime decompoſe this ſalt, does not yet ſeem to be determined.

Arſenic acid diſſolves alumine, and forms with it an arſeniat of alumine. This ſalt is not decompoſable in the fire without the addition of ſome combuſtible ſubſtance.

Barytes is readily diſſolved by arſenic acid; but at the point of ſaturation, theſe ſubſtances form an almoſt inſoluble arſeniat of barytes. The habitudes of this ſalt in the fire ſeem to be nearly the ſame with thoſe of arſeniat of lime.

Siliceous earth is not affected, either in the dry or moiſt way, by arſenic acid.

Carbonic acid is expelled by the arſenic, both in the humid and dry way, from its alkaline and earthy combinations.

Sulphuric acid has a ſtronger affinity for alkalis and earths, in the moiſt way, than the arſenic acid; but in the dry way, this acid expels the ſulphuric from the ſulphats of potaſh, ſoda, lime and barytes. An exceſs of arſenic acid, however, is neceſſary to produce this effect.

The nitric acid decompoſes, in the moiſt way, the arſeniats of alkalis, lime, barytes, and alumine, but not that of magneſia. The arſenic acid ſeems rather to take this earth from the nitric. In the dry way, the nitrats of alkalis and earths are decompoſed by the arſenic acid. In this proceſs, the arſenic acid does not decompoſe the nitric; but this effect takes place if the oxyd, inſtead of the acid of arſenic, be employed.

The magneſian is the only arſeniat which is not decompoſed by muriatic acid in the moiſt way. In the dry way, on the contrary, the muriatic acid is ſeparated from its alkaline and earthy combinations by the arſenic acid. The muriat of ſoda is not decompoſed by the oxyd of arſenic in the fire; that of ammoniac is decompoſed by arſenic acid; but if the fire be increaſed, the arſeniat of ammoniac will be decompoſed in its turn, and azotic gas, water, and white oxyd of arſenic, produced.

Fluoric acid has a ſtronger affinity, in the moiſt way, for alkalis and earths, than the arſenic acid; in the dry way, on the contrary, it is expelled, according to Scheele, from all its combinations, by this acid. In the latter caſe, however, an exceſs of acid is required.

Boracic acid has a leſs affinity in the moiſt way; but on account of its fixity, it cannot be ſeparated by arſenic acid in the dry.

Phoſphoric acid has a ſtronger affinity for both earths and alkalis, in the moiſt and dry way, than arſenic acid.

Tartaric acid ſeparates the arſenic from alkalis, and all the earths, except the magneſian. In the dry way, it yields to arſenic acid.

Oxalic acid, in the moiſt, is ſuperior, in the dry, inferior, to arſenic acid in its affinities.

Azotic acid, both in the moiſt and dry way, is inferior in its affinities to arſenic acid.

Succinic acid has a ſtronger affinity only for lime and barytes in the moiſt way; in the dry, it yields in all its combinations.

Citric is inferior only in its affinity for barytes in the moiſt way; in all, in the dry.

Malic acid inferior both in the moiſt and dry way.

Benzoic and Pruſſic inferior both in the moiſt and dry way.

Gold.—Arſenic acid has no action on gold, either in the moiſt or dry way; neither does it attack it when mixed, either with muriatic or nitric acids. Arſenic acid produces no precipitate in the ſolution of gold. It is probable, however, that this acid diſſolves the oxyd of gold, and forms with it an arſeniat of gold; for arſeniat of ſoda precipitates gold, in its metallic ſtate, from its ſolution in acids.

Platina ſeems to have nearly the ſame habitudes with acid of arſenic as gold.

Silver is not acted on in the moiſt way by arſenic acid. Diſtilled together in a retort, with a briſk heat, a portion of the white oxyd of arſenic is ſublimed, while the remaining portion is united to the oxyd of ſilver, forming a colourleſs glaſs, which, by ſolution in hot water, affords a brown powder. This ſolution contains arſeniat of ſilver, which affords *luna cornea*, or the muriat of ſilver, by the addition of muriatic acid. The arſeniats of alkalis and earths precipitate ſilver, from its ſolution in nitric acid, by double affinity. Arſeniat of ſilver is decompoſed by fire. The arſenic is ſublimed in the form of an oxyd, while the oxyd of the ſilver is reduced to the metallic ſtate. Although ſilver is not ſoluble either in muriatic nor in arſenic acids, yet a remarkable combination is produced by a mixture of theſe two acids. If powder of ſilver be digeſted with a mixture of two parts of the arſenic, and two of the muriatic acids, the ſilver is converted firſt into a white powder, and afterwards into *luna cornea*, or muriat of ſilver. In this proceſs, the ſilver is converted into an oxyd by the arſenic acid, which afterwards unites with the muriatic acid.

Mercury has no action, in the moiſt way, on acid of arſenic. Diſtilled together to dryneſs by a briſk heat, a yellow maſs is formed, and ſome mercury, with arſenic, paſſes over into the receiver. The yellow maſs is arſeniat of mercury. This ſalt is ſoluble in muriatic, but not in nitric or ſulphuric acids. The ſolution of this combination in muriatic acid affords corroſive ſublimate by diſtillation. Arſeniat of mercury is decompoſable by itſelf alone in cloſe veſſels; the products are mercury and oxyd of arſenic. The ſolution of mercury in nitric and ſulphuric acids is precipitated by the arſenic acid; corroſive ſublimate, or the oxygenated muriat of mercury, is not acted on either in the moiſt or dry way; but calomel, or the mild muriat of mercury, is converted into corroſive ſublimate by diſtillation with this acid. The ſublimate, in this caſe, always contains a little oxyd of arſenic. A mixture of muriatic and arſenic acids produce the ſame effects on mercury as on ſilver.

Lead becomes black by digeſtion with arſenic, and after a few days it is covered with a powder of a white grey colour, that is mixed with a little oxyd of arſenic, from which it may be ſeparated by expoſure to heat; but the acid contains no lead diſſolved in it. A more powerful action is produced by diſtilling two parts of arſenic acid with one of filings of lead. The mixture becomes colourleſs; ſome oxyd of arſenic is ſublimed, and a white milky coloured glaſs left behind in the retort, which is an arſeniat of lead. The ſuperabundant acid may be ſeparated by boiling in water. The arſeniat of lead is eaſily decompoſed by the addition of charcoal in the fire, as it is arſenic acid, rather than white oxyd, that is ſeparated while the lead is reduced. The arſeniat of lead may alſo be procured by boiling a ſolution of nitrat of lead with oxyd of arſenic.

The arſenic acid precipitates lead from its ſolution in acetic, nitric, and muriatic acids; and the alkaline and earthy arſeniats decompoſe all the ſolutions of lead in acids. It is from this laſt property of arſenic acid that Richter has propoſed a new method of obtaining this acid in a very pure ſtate. A ſolution of arſeniat of potaſh, prepared by the diſtillation of oxyd of arſenic with nitrat of potaſh, is to be poured into a ſolution of acetat of lead, ſo long as any precipitate continues to be formed. After this precipitate has fallen to the bottom, the ſupernatant liquor is to be poured off, and the precipitate carefully waſhed. Sulphuric acid, in the proportion of one to three parts of the acetat of lead employed, is now to be added, having been previouſly diluted with an equal quantity of water. This mixture is to be ſtirred frequently, and after a few hours ſulphat of lead will be formed, which remains at the bottom. The clear fluid which ſwims above is to be poured off and filtered, after it has been previouſly diluted with water. This liquor is arſenic acid. It is to be deprived of its water by evaporation, and of any ſulphuric acid which it may contain, by expoſing it to a ſtill ſtronger heat. *Richter, neu. Gegenſtande, Stuck*, ſ. 35.

Biſmuth is converted into a white powder by digeſtion in arſenic acid, which is an arſeniat of biſmuth. This ſubſtance is precipitated from the ſolution by the addition of water. In the dry way, arſenic acid oxydates, but does not diſſolve biſmuth. This metal is precipitated from its ſolution in nitric acid by dry arſenic acid. The arſeniat of biſmuth which is formed, is exceedingly difficult of ſolution in water. It is eaſily reduced by charcoal in the fire.

Nickel is attacked by digeſtion with arſenic acid, and the ſolution has a green colour. A conſiderable quantity of a green powder falls to the bottom, which is mixed with arſenic, but which may be driven off by a briſk fire. One part of nickel in powder, diſtilled with two of dry arſenic acid, fuſes, according to Scheele, and oxyd of arſenic is obtained during the proceſs. A yellow maſs remains after cooling. By boiling this in water, arſeniat of nickel is obtained. This ſalt is eaſily reduced by charcoal in the fire, and the arſenic reduced to its metallic ſtate. Arſenic acid does not precipitate nickel from its ſolution in acids. Alkaline and earthy arſeniats precipitate it, however, in the form of a whitiſh grey powder.

Copper gives a green ſolution by digeſtion with arſenic acid. A blueiſh white powder falls to the bottom, which is arſeniat of copper. One part of copper filings, diſtilled to dryneſs, with two of dry arſenic acid, gives out oxyd of arſenic. The remainder is an arſeniat of copper. Arſenic acid precipitates copper only from its ſolution in acetic acids. Arſeniat of copper, which fuſes into a glaſſy ſubſtance in the fire, is eaſily decompoſed by the addition of combuſtible bodies. During this proceſs, white oxyd of arſenic is diſengaged.

Zink is the only metal that effervеſces when digeſted with arſenic acid. The zink grows black, and the tranſparency of the acid is deſtroyed by a black powder. If this powder be ſeparated, dried, and placed on an iron plate, heated nearly red hot, it burns with a blue flame, and emits a white arſenical ſmoke. Hydrogen is diſengaged during the digeſtion in arſenic acid, a proof that the zink is firſt oxydated by the decompoſition of water, and afterwards diſſolved by the acid. If zink filings be heated on a ſtrong fire with acid of arſenic, a violent inflammation and exploſion takes place. Arſenic and oxyd of zink are ſublimed during this exploſion into the neck of the retort; only the acetic ſolution of zink is precipitated by arſenic acid. Neutral arſeniats decompoſe all the acid ſolutions of zink.

Antimony forms a white powder by digeſtion in arſenic acid. If diſtilled together to dryneſs, an inflammation takes place as ſoon as the maſs enters into fuſion. The ſolutions of antimony in acetic and tartaric acids are precipitated by the acid of arſenic.

The arſenic acid aſſumes a roſe colour by digeſtion with cobalt; but a great part of the cobalt remains undiſſolved. Arſenic acid does not precipitate cobalt from its ſolutions in acids; but the alkaline and earthy arſeniats produce a precipitate of a roſe colour. This precipitate is fuſed with extreme difficulty in the crucible.

Acid of arſenic diſſolves a little mangaueſe during digeſtion. Fixed alkalis precipitate from it a white powder. If manganeſe be diſtilled with acid of arſenic oxyd of arſenic is ſublimed. The ſolution of manganeſe in acetic acid is precipitated by the acid of arſenic; not ſo its ſolution in other acids. Arſeniats have alſo this effect.

Arſenic acid converts, by digeſtion, arſenic into the ſtate of an oxyd, while the acid itſelf returns to the ſame ſtate. If powder of arſenic be thrown into a retort on melted arſenic acid, an inflammation takes place, and oxyd of arſenic is ſublimed. See *Gren's Handbuck der Chemie.*

z Arſenic, as well as its oxyd, unites in the fire with almoſt all metallic bodies. In the ſtate of oxyd it ſeems to oxydate a portion of the metal with which it combines.

This combination changes the properties of metals. The malleable becomes brittle, the fixed eaſily fuſible, and the eaſy fuſible fixed. Thoſe which are yellow or reddiſh become more or leſs white, and the white of a greeniſh or tin colour. The arſenic may be ſeparated again by expoſure to a ſtrong heat in open veſſels, but it carries off a portion of the metal along with it. Platina alone remains fixed in the fire

Gold and arſenic unite together. When melted in the fire the gold takes up about 1-60th. When the operation is performed in cloſe veſſels the mixture becomes cracked and brittle. The arſenic cannot be completely ſeparated from the gold by mere heat without the addition of ſome combuſtible body, ſuch as ſulphur, &c. Oxyd of arſenic, with the addition of a little alkali, unites alſo in the dry way to gold, but the ſolution of the oxyd in water does not produce any effect. The ſolution in *aqua regia* is ſaid by Newman to be precipitated of a pale yellow colour. Sulphure of arſenic and the arſeniats readily produce a precipitate, but they ſeem to do this rather by the alkali than by the arſenic which they contain. It is remarkable that arſeniat of ammoniac does not produce a ſulminating oxyd of gold. Arſenic precipitates gold from its ſolution in *aqua regia.*

If arſenic and platina be melted together in a crucible, a brittle grey maſs is produced. The fuſion is promoted by the addition of a little alkali, which fixes the arſenic. The arſenic is ſeparable by mere heat, and leaves the platina in a malleable ſtate. Two parts of platina, accurately mixed with one of arſenic and tartar, when expoſed to a glow heat in a luted crucible, melt into a brittle ſubſtance, which is ſtill whiter than platina. This ſubſtance is eaſily ſoftened by the fire, or, by a ſtronger heat, completely melted. In this ſtate, if expoſed for a ſufficient length of time to the fire, the arſenic is diſſipated, and the platina, which again becomes ſolid, alone remains. Achard has taken advantage of this property to form veſſels of all ſorts from platina, a ſubſtance ſo infuſible by itſelf. Arſenic precipitates platina from its ſolution in *aqua regia*. The oxyd of arſenic has not this effect. Arſeniats and liver of arſenic alſo produce precipitates; but this more from the alkali probably than from the arſenic. *Achard, Crell's Chem. Ann.* 1784, B. I. ſ. 3.

Arſenic, by the addition of a little alkali, unites readily with ſilver. The mixture is brittle. The arſenic is not ſeparable by heat alone; but this effect is eaſily produced by melting it with charcoal; or, ſtill better, by uniting it to lead. The arſenic carries off a portion of the ſilver along with it. Powder of arſenic precipitates ſilver from its ſolution in nitric acid. The ſame effect is produced by a ſolution of the oxyd in water; but in this caſe the precipitate is a combination of the oxyd of ſilver with the oxyd of arſenic. The arſeniats and liver of arſenic produce a precipitate by double affinity, which is arſeniat of ſilver.

Arſenic forms, by long trituration in the heat, a grey amalgam with mercury; but the oxyd does not unite by ſublimation with this metal. Arſenic precipitates mercury in its fluid ſtate from its ſolutions in ſulphuric and nitric acids. A ſolution of the oxyd, or of ſulphure of arſenic, added to the ſolution of mercury in acids, produces a precipitation of arſeniat of mercury which is not ſoluble in water. If it be expoſed to heat with charcoal the arſenic ſublimes with its peculiar ſmell, and the mercury paſſes over into the receiver. Corroſive mercurial muriat is not decompoſed by oxyd of arſenic, but if equal parts of this ſalt and powder of arſenic be rubbed together, and diſtilled with a briſk heat, a ſmoking *butter*, or oxygenated muriat of arſenic paſſes over, and, by increaſing the fire, fluid mercury riſes containing a little calomel. If mercury be rubbed with yellow or red arſenic, and afterwards ſubjected to the proceſs of ſublimation, white oxyd of arſenic riſes firſt, and afterwards a true cinnabar, which ſtill retains a little arſenic. This may be ſeparated by a new ſublimation. Sulphur has, therefore, a ſtronger affinity for mercury than for arſenic.

If from two to three parts of corroſive mercurial muriat be mixed with one of *orpiment*, and diſtilled in a ſand bath, *butter of arſenic* will be produced. No mercury in this caſe paſſes over in the fluid ſtate, but it remains united to the ſulphur, and may be ſublimed by a ſtrong fire in the ſtate of cinnabar.

Lead unites with about one ſixth part of its weight of arſenic. In a briſk fire the mixture begins to ſmoke, and ſwells up. One part paſſes over in the form of thick ſmoke; another is converted into a red glaſs, and the remaining lead becomes brittle and of a dark colour. The arſenic may be ſeparated from the lead by repeated roaſtings with charcoal. The ſolution of oxyd of arſenic has no action on lead, but it precipitates lead from its ſolution in ſulphuric, nitric, and acetic acids. This precipitation is more ſpeedily produced by the ſulphure of arſenic. If a ſolution of nitrat of lead be boiled with oxyd of arſenic, a large quantity of nitrous gas is diſengaged, and the oxyd of lead remains combined with the arſenic acid. Sulphur has alſo a ſtronger affinity for lead than arſenic; ſo that if the *red arſenic* be expoſed with lead to a ſufficiently ſtrong fire, white oxyd of arſenic will be ſublimed.

Biſmuth unites to arſenic in only a ſmall quantity, 1-15th. The mutual affinities of theſe metals for acids is not known. Arſenic has a leſs affinity for ſulphur than biſmuth. A ſolution of oxyd of arſenic has no action on biſmuth. Sulphure of arſenic precipitates biſmuth from its ſolution in acids in the ſtate of an oxyd, but mixed with a ſmall portion of arſenic, which may be ſeparated by roaſting it with charcoal.

Nickel has a ſtrong attraction for arſenic, and is very difficultly ſeparated from it even by roaſting the mixture with charcoal. The ſolution of oxyd of arſenic ſeems to act on the nickel; but the nickel has a ſtronger affinity for acids and ſulphur than arſenic.

Copper, when in large quantity, unites readily with arſenic, and forms with it a brittle mixture, of a red colour; with arſenic it forms white tomback, or white copper, which continues to be flexible and malleable if the arſenic be uſed in its metallic and not in its oxydated ſtate. In preparing this ſubſtance it is neceſſary to diminiſh the fluidity of the arſenic by the addition of ſome fixed alkali. Very beautiful tomback is prepared, according to Leonhardi, by melting equal parts of black flux and copper filings with four parts of oxyd of arſenic, under a covering of powdered glaſs. White copper becomes black in the air, ſo that it is neceſſary to give it a covering of ſilver. Copper has a ſtronger affinity for acids and ſulphur than arſenic; but oxyd of arſenic unites in the humid way with oxyd of copper, and diſſolves the copper itſelf. This ſolution is neither decompoſed by acids nor alkalis; and by evaporation it affords a yellow-greeniſh ſaline ſubſtance, which ſeems to be arſeniat of copper. Ammoniac does not give a blue colour to this ſolution. The oxyd of arſenic precipitates copper from its ſolution in ſulphuric and vegetable acids of a green colour. The precipitate is arſeniat of copper. This affords a method of diſcovering the preſence of arſenic in water. The ſolution of the ſulphat of copper affords a precipitate of a green colour, which the ammoniac does not colour blue as it does the other precipitates of copper. On this property depends the preparation of a beautiful green paint, firſt diſcovered by Scheele. Two pounds of ſulphat of copper are to be diſſolved in a copper kettle in twelve pounds of water. To this two pounds of dry potaſh and eleven ounces of white arſenic, with four pounds of water, are to be added, and the mixture carefully ſtirred during the addition. It is neceſſary to uſe a large veſſel on account of the effervеſcence which takes place. After the mixture has been allowed to ſettle, the clear liquor is to be decanted off, and the precipitate well waſhed with water, and dried in a gentle heat.

CHAPTER VII.

CONCERNING MOLYBDENA AND THE MOLYBDIC ACID.

We give the name of *molybdena* to a new metal, diſcovered by Mr. Hielm, and obtained from a mineral ſubſtance known by the ſame name. This ſubſtance muſt not be confounded with common black lead, plumbago, or black chalk which is uſed in drawing, and is at preſent denominated *carbure* of iron: this confuſion has certainly occaſioned ſome difference of reſults in the labours of thoſe chemiſts who have examined this ſubſtance, from the time of Pott to that of Scheele. It muſt be obſerved, that the carbure of iron, or plumbago, being much more common than molybdena, very few ſpecimens of which are to be met with in cabinets of natural hiſtory, chemiſts have almoſt always made their experiments with the former, Quiſt and Scheele excepted.

The true ore of molybdena is not eaſily diſtinguiſhed from carbure of iron, in its external characters; nevertheleſs, the molybdena is rather leſs fat to the touch. It is compoſed of hexagonal ſcales, of greater or leſs ſize, very ſlightly adhering to each other: it ſoils the fingers, and leaves traces upon paper, which are bluiſh, or of a ſilvery grey colour. When it is reduced to powder, which is difficult to be performed, on account of the elaſticity of its ſcales, it has a blueiſh colour; it yields eaſily to the knife, is not brittle, and has not the granulated texture of carbure of iron. In order to pulverize the ore of molybdena, it is neceſſary, after the proceſs of Scheele, to throw a ſmall quantity of ſulphat of potaſh into the mortar along with it; the powder muſt afterwards be waſhed with hot water, which carries off the ſalt, and the mineral remains pure. The analyſis of this mineral, made by different means, proves that it is a compound of ſulphur and the metal which we are now examining. This laſt, however, is very difficult to be obtained: the illuſtrious Scheele did not ſucceed in reducing its oxyd into metal, either with black flux and charcoal, or with borax and the ſame combuſtible ſubſtance, nor with oil. Bergman affirms, that Mr. Hielm has been more fortunate, and that he ſucceeded in obtaining a ſufficient quantity of the ſemi-metal to exhibit its properties; but ſince the time of this note of Bergman, Mr. Hielm has publiſhed nothing on the ſubject *. Pelletier, in his experiments on the reduction of the oxyd and acid of molybdena, never obtained a button of molybdena, but an agglutinated, blackiſh, friable ſubſtance, poſſeſſing the metallic brilliancy: by the magnifier, ſmall, round, brilliant, and greyiſh grains were ſeen, which Pelletier conſiders as the metal or pure molybdena. Manganeſe likewiſe has not yet been obtained, except in the form of globules.

The following are the properties which have been obſerved, in conſequence of the trials made of this ſemi-metal. Molybdena is grey, in the form of ſmall agglutinated grains, brittle, and extremely infuſible: when heated in contact of air, it changes into a white oxyd, which is volatile, and cryſtallizes by ſublimation into brilliant needle-formed priſms, reſembling thoſe of antimony. This oxyd, when ſuperſaturated with oxygen, becomes acid, and is the ſaline product which is beſt known, in conſequence of the reſearches of Scheele. The nitric acid readily calcines, and converts it into a white oxyd, and even into molybdic acid. The oxyd of molybdena becomes blue and brilliant during its tranſlation to the metallic ſtate[a]. Alkalis, aſſiſted by the action of water, oxydate and diſſolve this ſemi-metal[b]; it is capable of uniting with lead, copper, iron, ſilver, and forms granulated, greyiſh and very friable alloys. Laſtly, When combined with ſulphur, it conſtitutes the ſulphure of molybdena, a compound which is perfectly ſimilar

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* A paper of Mr. Hielm on this ſubject has been lately publiſhed in the *Journal de Phyſique* for May 1789, tranſlated from the Swediſh Tranſactions. It contains an account of the habitudes of the oxyd of molybdena with ſome of the metals, and an account of ſome trials to reduce it. The regulus, which was ſent to Bergman, was obtained as follows: Vegetable alkali was neutralized by repeated fuſions with bullock's blood; the earth of molybdena was heated with a ſmall quantity of greaſe, which gave it the appearance of a black powder. Equal parts of this alkali and of microcoſmic ſalt, together with a ſmall quantity of black-flux, were uſed for the reduction, common ſalt being uſed ſometimes to cover the whole, and ſometimes mixed with it. The fuſion was made in a covered and luted crucible, expoſed to the heat of a good furnace for ſeveral hours.—*Note of th Tranſlator.*

to the ore of this metal, improperly known by the names of *molybdena* and *potelot* [c]. As it is this laſt ore which has been the ſubject of the experiments of Scheele, and as it is with this mineral, which is much better known than the metal it contains, that this chemiſt prepared the acid of molybdena, we ſhall proceed to examine its properties more at large.

Potelot, or native ſulphure of molybdena, expoſed to heat in an open veſſel, gives out ſulphur, and evaporates almoſt totally in the form of a white ſmoke: expoſed to the flame of a lamp, urged by a blow-pipe, in the metallic ſpoon, it emits the ſame fumes, which are condenſed into yellowiſh cryſtalline blades, and aſſumes a blue colour, by the contact of combuſtible ſubſtances. Pelletier having calcined the ſulphure of molybdena in a crucible covered by another crucible, obtained white, brilliant, needle-formed cryſtals, ſimilar to thoſe which are called the *ſilvery flowers of antimony*. This ſublimed oxyd of molybdena already poſſeſſes the characters of an acid; but this proceſs would be too tedious and expenſive to be uſed in the preparation of the acid of molybdena.

Saline earths and fixed alkalis, fuſed with the ſulphure of molybdena, diſſolve both the ſulphur and the metal.

Some acids produce remarkable alterations in this ore.

The concentrated ſulphuric acid oxydates or calcines the metal, and flies off in the form of ſulphureous acid, by the aſſiſtance of a boiling heat.

The muriatic acid has no action on this mineral.

The arſenical acid, diſtilled from the ſulphure of molybdena, yields its oxygen to part of the ſulphur, which becomes ſulphureous acid. It is volatilized in the form of *orpiment* with part of the ſame ſulphur, changes a portion of the molybdena into the molybdic acid, and leaves the greateſt part in the metallic ſtate. Pelletier concludes, from this experiment, that molybdena exiſts in the metallic ſtate in its ore.

By diſtilling 30 ounces of nitric acid diluted with water, from 1 ounce of molybdena, at five ſucceſſive operations that is to ſay, 6 ounces of the acid at a time, a great quantity of nitrous gas is diſengaged, and a white powder remains in the retort, which muſt be waſhed with a ſufficient quantity of cold diſtilled water to carry off the foreign acid, which is ſoluble at this temperature. After the edulcoration, there remain ſix drachms and a half of the pure molybdic acid. Scheele, to whom this diſcovery is due, thinks that the nitric acid ſeizes phlogiſton, and eſcapes in red vapours; it likewiſe burns the ſulphur which exiſts in the molybdena, and hence it is that the water employed in waſhing the acid of molybdena contains ſulphuric acid; which may be obtained in a concentrated ſtate by evaporation, and holds a ſmall quantity of molybdena in ſolution. This ſubſtance gives a blue colour of conſiderable brilliancy to the liquor. We are of opinion, that, in this operation, as well as in all thoſe in which the nitric acid, diſtilled from any ſubſtance whatever, reduces it into the ſtate of acidity, the former is decompoſed; and that it is to the ſeparation of the oxygen of the nitric acid, and its fixation in the molybdena, that the diſengagement of the nitrous gas and the formation of the ſulphuric and molybdic acids are owing.

The acid of molybdena, obtained by the proceſs we have juſt deſcribed, has the form of a white powder, of a ſlightly acid and metallic taſte. When heated in the ſpoon by the blowpipe, or in the crucible with the contact of air, it is volatilized in a white fume, which is condenſed in needle-formed cryſtals, at the ſame time that part is melted on the ſides of the crucible: notwithſtanding the edulcoration, it retains a portion of ſulphureous acid, which a ſtrong heat completely diſengages.

This acid is ſoluble in boiling water. Scheele diſſolved a ſcruple in 20 ounces of water: this ſolution has a ſingularly acid and almoſt metallic taſte; it reddens the tincture of turnſole, decompoſes the ſolution of ſoap, and precipitates alkaline ſulphures, or *livers of ſulphur*. It becomes blue and conſiſtent by cold.

The molybdic acid diſſolves in great quantities in the concentrated ſulphuric acid, by the aſſiſtance of heat. This ſolution aſſumes a fine blue colour, and becomes thick by cooling. Both phenomena may be made to diſappear by heat, and reappear again in proportion as the fluid cools. If the combination be ſtrongly heated in a retort, the ſulphuric acid is volatilized, and the molybdic acid remains in a dry ſtate at the bottom of the veſſel[d].

The nitric acid has no action on the molybdic acid.

The common muriatic acid diſſolves a large quantity. This ſolution affords a reſidue of a deep blue colour, when diſtilled to dryneſs. If the fire be more ſtrongly urged, the reſidue affords a white ſublimate, and another blueiſh; a grey reſidue remaining in the retort. The ſublimate is deliqueſcent, and colours metals blue: the muriatic acid paſſes oxygenated into the receiver. It is eaſy to underſtand, that, in this operation, the muriatic acid deprives the molybdic acid of a portion of oxygen, and that a portion of this acid paſſes to the ſtate of molybdena[e].

The molybdic acid, by the aſſiſtance of heat, decompoſes the alkaline nitrats and muriats, by diſengaging their acids, and forms with their baſes neutral ſalts, whoſe properties Scheele did not examine. This acid likewiſe diſengages the carbonic acid from the three alkalis, and forms neutral ſalts with their baſes.

Though Scheele has not made us acquainted with all the properties of the neutral ſalts which we deſign by the names of molybdats of potaſh, of ſoda, of ammoniac, &c. he has nevertheleſs pointed out three, which are ſufficient to characterize their ſtate of neutralization. He has diſcovered, 1. That fixed alkali renders the acid of molybdena more ſoluble in water. 2. That this ſalt prevents the acid of molybdena from volatilization by heat. 3. That the molybdat of potaſh falls down by cooling in ſmall cryſtalline grains, and that it may likewiſe be ſeparated from this ſolvent by the ſulphuric and muriatic acids[f].

The acid of molybdena decompoſes the barytic nitrat and muriat. The barytic molybdat, formed in theſe operations, is ſoluble in water.

The acid of molybdena appears partly to decompoſe the ſulphat of potaſh by a ſtrong heat.

The molybdic acid diſſolves ſeveral metals, and aſſumes a blue colour in proportion as this acid abandons to them part of its oxygen. It precipitates ſeveral metallic ſolutions, &c. Klaproth has found it combined with lead in a yellow ſpathic ore of lead[g].

NOTES ON CHAPTER VII.

MOLYBDENA.

[a] Molybdena, according to Mr. Hatchett, in his valuable analyſis of the Carinthian molybdat of lead (*Phil. Tranſ.* for 1796), ſeems to exiſt in four different degrees of oxygenation. The firſt is that of the black oxyd, the ſecond the blue oxyd, the third the green oxyd, which ſeems to be an intermediate degree between the blue oxyd and the fourth and laſt ſtate, that of the yellow acid.

The affinity of this metal for oxygen ſeems to be very weak, for very conſiderable changes are produced in it by a very ſmall difference in the proportion of the acids or alkalis with which it is combined, or the temperature to which it is expoſed. In confirmation of this alſo, it may be remarked, that Scheele and Iſlmann have obſerved, that all metals, gold and platina excepted, deprive the molybdic acid of a portion of its oxygen, ſo as to cauſe it to become blue. Pelletier obſerved, that a ſolution of molybdic acid became blue, when hydrogenous gas was paſſed through it. Klaproth remarked, that light, in certain circumſtances, changed the colour of molybdic acid to blue. The ſame phenomena were obſerved by Mr. Hatchett. Molybdic acid yields its oxygen in diſtillation to arſenic, by which the arſenic is converted into the white oxyd. The molybdic is alſo the only metallic oxyd which is deprived of its oxygen by diſtillation with ſulphat of ammoniac.

[b] The fixed and volatile alkalis have no action in the moiſt way on this metal, but they diſſolve its oxyd with great facility. Molybdena enters readily into fuſion with the fixed alkalis. If one part of this fuſed ſubſtance be melted with three parts of ſoda, a dark green matter is produced, which is ſoluble in water. With acids, this ſubſtance affords a yellow precipitate, or the acid of molybdena.

[c] Twenty grains of yellow acid, diſtilled with 100 grains of ſulphur, afforded a black reſidue, which ſeemed to poſſeſs all the properties of ſulphure of molybdena. Treated with nitric acid, this black matter afforded the yellow acid.

[d] A white flocky matter is precipitated when this ſolution is ſaturated with ſoda, which is again converted into a yellow powder, by heating it with nitric acid.

Muriat of tin does not produce any effect on this ſolution. When the ſolution, however, is ſaturated with potaſh, the muriat of tin is precipitated, highly tinged, of a blue colour; but when the acids are again added, muriat of tin has no effect.

[e] Fluoric acid diſſolves the oxyd of molybdena. The mixture in the heat is of a greeniſh yellow colour; by evaporation it becomes yellow, and when diſtilled to dryneſs, of a greeniſh blue. The dry maſs communicates a dull graſs-green colour to the water uſed to edulcorate it, and the reſidue has a beautiful green colour.

Boracic acid, in the moiſt way, has no action on oxyd of molybdena. The phoſphoric diſſolves it by the aſſiſtance of heat, and affords, by the evaporation of its watery parts, a blue ſolution.

Tartaric acid diſſolves readily, by the aſſiſtance of water and heat, the oxyd of this metal, and affords by evaporation a blue ſolution. The evaporated maſs is of a pale blue.

Oxalic acid and water form with oxyd of molybdena a beautiful blue ſolution, which preſerves its colour during evaporation. Diluted with a little water, it becomes green, with a larger quantity, dark brown.

Acetic and benzoic acids form beautiful blue ſolutions with the aſſiſtance of water and heat.

Pruſſian alkali precipitates the oxyd of molybdena from its ſolution in acids of a brown colour; the infuſion of gall nuts, of a dark brown colour.

f The nitric and concentrated acetic acids decompoſe the molybdat of potaſh. The molybdic acid is diſengaged from this combination ſometimes in the form of a white powder, and at other times in the ſtate of a liquid. Perhaps this depends on a difference in the degree of oxygenation, as this metal appears to become more ſoluble in proportion to its oxygenation.

Molybdat of ſoda cryſtallizes by evaporation, partly into broad tender ſpiculæ, and partly into dendritical cryſtals. It is very ſoluble in water, and is decompoſed by the ſame acids as molybdat of potaſh.

Molybdat of ammoniac does not afford any regular cryſtals by evaporation, but forms a white pulverulent magma. This ſalt is decompoſed in the fire, the molybdic acid remaining in the retort.

Lime forms with this acid a very inſoluble ſalt. It is precipitated by adding molybdic acid to lime water. The ſulphuric, nitric, and muriatic acids, decompoſe the molybdat of lime.

Magneſia forms with this acid a ſalt which is difficultly ſoluble in water, according to Scheele. It is decompoſed by the ſame acids as the former. Heyer ſays it has a ſoapy feel and a bitter taſte.

The molybdat of alumine is very difficultly ſoluble in water.

With barytes this acid forms a very ſoluble ſalt. It takes this earth from its ſolutions in nitric and muriatic acids.

When one part of molybdic acid is expoſed in a retort with two of nitre, the nitre is decompoſed, and molybdat of potaſh formed.

Two parts of gold, with one of molybdena, expoſed to a ſtrong fire in a crucible, covered internally with charcoal duſt, melted together into a black brittle maſs. By repeated meltings without the charcoal, in a covered crucible, ſome of the gold was ſeparated. The remaining maſs, melted with charcoal, gave a greyiſh yellow uniformly brittle maſs. Nitric acid was decompoſed by boiling it over this maſs. The gold was found at the bottom, and over it white oxyd of molybdena. Equal parts of theſe metals afford a brittle black yellow mixture, the habitudes of which were little different from the former.

Equal parts of platina and molybdena melt together into hard ſhapeleſs maſſes, of a metallic ſplendour, and eaſily broken.

From two parts of ſilver no round grain is produced, even after repeated meltings. If the melting be performed in a covered crucible, without charcoal, a part of the ſilver is ſeparated, which is flexible, but which in ſolution ſhows ſome marks of molybdena. One part of ſilver, with two of molybdena, melted into a uniformly granular brittle greyiſh maſs. The molybdena was diſſipated in the form of ſmoke by expoſing this mixture to heat in contact with charcoal.

Mercury is not amalgamated by long rubbing with molybdena.

Lead and molybdena are not eaſily melted together, on account of the eaſy fuſibility and oxydation of lead in the fire. Two parts of lead, with one of molybdena, melted in a crucible with ſome charcoal, becomes a black and brittle maſs.

Biſmuth unites, but on account of its volatility, with difficulty, to molybdena.

Equal parts of nickel and molybdena melt with charcoal into a light grey body, which is infuſible by itſelf or in borax.

Copper melts with molybdena. The mixture is paler than copper, and poſſeſſes malleability if the proportion of molybdena does not exceed that of the copper.

It is doubtful whether arſenic can be united to molybdena on account of its great volatility.

Iron, of all metals, unites moſt readily, and in the greateſt quantity, with molybdena. Equal parts melt without any loſs into a round body. The mixture is hard, brittle, and of a blue grey fracture. It melts and ſwells by the blow pipe without emitting ſparks. Muriatic and ſulphuric acids act weakly on this mixture; aqua regia more powerfully.

Cobalt and molybdena, in equal parts, melt together into a light grey brittle mixture. Nitric acid attacks this powerfully in a boiling heat. The white acid of molybdena is ſeparated from the red ſolution.

Tin, in an equal proportion, affords a black, granular, brittle and ſoft maſs, when melted with molybdena.

The combination of zink with molybdena is difficult, if not impoſſible, from its fluidity.

The ſame is true of antimony.

Manganſe forms a brittle and difficultly fuſible mixture with molybdena; and precipitates oxyd of molybdena from its ſolution in nitric acid. *Richter Neu. Gegenſt. St. I. ſ. 49. St. II. ſ. 97, 104.*

g This acid, in ſolution, has likewiſe ſome effect on metals. By boiling them together, it acquires a bluiſh caſt. If, inſtead of the metals, their oxyds be digeſted in this acid, no blue colour ariſes. This colour is deſtroyed alſo by digeſtion with nitric acid.

Acid of molybdena precipitates ſilver, mercury, and lead, from their ſolutions in nitric acid. It decompoſes muriat of lead, but not corroſive muriat of mercury.

The alkaline molybdats precipitate from their ſolution in acids, gold, mercury in oxygenated muriatic acid, zink, and manganeſe, in the form of a white powder; iron and tin from muriatic acid of a brown; cobalt, of a roſe colour; copper, of a blue.

Blue carmine is prepared by precipitating tin from its ſolution in muriatic acid by the molybdat of potaſh. The muriatic acid unites with the alkali, and the molybdic with the tin, to form the blue precipitate.

Iron forms a brown-red ſolution by digeſtion in this acid. If a little ſulphuric acid be added to the ſolution, the molybdic acid is ſeparated, and remains diſſolved in the liquor. Sulphat of iron is decompoſed by double affinity with molybdat of potaſh. The molybdic acid alone does not produce this effect.

Copper forms a blue-green ſolution with molybdic acids. Sulphuric and nitric acids produce no apparent change in this ſolution; but no inference reſpecting the decompoſition can be inferred from this circumſtance, as the colours of the molybdat, ſulphat, and nitrat of copper, are nearly the ſame.

Lead, in the ſtate of an oxyd, is acted upon by molybdic acid; but this combination is again decompoſed by the mineral acids. It is ſtill more inſoluble in water than ſulphat of lead. This property affords a ready teſt for diſcovering the preſence of lead in liquors. If two or three drops of a ſolution of nitrat of lead be mixed with a quart of pure water, and a little of an alkaline molybdat dropped into the liquor, a white precipitation is immediately produced. This precipitate, which is molybdat of lead, is not acted upon by any of the vegetable acids. This ſalt does not deliqueſce in the air, and is on that account to be preferred to the uſual teſt for trying the purity of wines.

Mr. Hatchett has given a full and accurate analyſis of the native molybdat of lead. According to this chemiſt, the native molybdat of lead melts readily with the blow-pipe into a dark coloured maſs, in which ſome ſhining particles of lead are to be perceived. With borax it forms a browniſh-yellow globule, and occaſionally a glaſs, which is of a greeniſh, and ſometimes of a deep blue. With phoſphat of ammoniac and ſoda, it forms a ſea-green glaſs, which, in proportion to the quantity of ore, varies to a deep blue.

Molybdat of lead is inſoluble in water. Fixed alkalis and their carbonats decompoſe it in the dry and humid way, but ammoniac does not ſeem to have any effect.

Molybdat of lead, diſtilled with three parts of ſulphur, affords a black powdery reſiduum, which is greaſy to the touch, and ſoils the fingers like molybdena.

Molybdat of lead is diſſolved by digeſtion in muriatic acid. Muriat of lead is depoſited by evaporation, and the molybdic acid remains ſuſpended in the ſolution.

Molybdat of lead is decompoſed by boiling it with concentrated ſulphuric acid. The ſulphat of lead which is formed remains at the bottom, while the molybdic acid is ſuſpended in the exceſs of the ſulphuric acid which is employed, and communicates to it a blue colour.

Digeſted with nitric acid, a great part of the molybdat of lead is diſſolved. In the ſolution white flocculi appear, which may be ſeparated by a filter. When dried, theſe flocculi form a membranous kind of ſubſtance, which becomes bluiſh when expoſed to the light, and which has a ſtrong reſemblance to the molybdic acid obtained by repeatedly diſtilling nitric acid from molybdena. It does not, however, appear poſſible to decompoſe the molybdat completely by means of this acid.

The habitudes of molybdat of lead with neutral ſalts are as yet but little known. The molybdic acid ſeems, however, to be capable of forming triple ſalts with the different acid combinations of ammoniac. During this combination, a portion of the ammoniac is decompoſed. While one part of it eſcapes under the form of azotic gas, the other combines with the hydrogen of the molybdic acid to form water.

Nitrat of ſilver is not decompoſed by the addition of ſimple molybdic acid, but an extremely white precipitate is immediately produced by the addition of an alkaline molybdat. This precipitate, which is difficultly ſoluble in water, diſſolves readily in nitric acid.

A ſolution of gold in *aqua regia*, or in oxygenated muriatic acid, is not changed by molybdic acid, but a beautiful yellow coloured powder is precipitated by the addition of an alkaline molybdat. This ſolution, which is partly ſoluble in water, is wholly ſo in common muriatic, or in diluted nitric acid.

Platina diſſolved in aqua regia, and mixed with a ſolution of an alkaline molybdat, ſpeedily affords a red precipitate, which is ſoluble in from 80 to 100 times its weight of water. It is not acted upon by the nitric nor muriatic acids, nor even by aqua regia.

A ſaturated ſolution of mercury in nitric acid is decompoſed by the addition of an alkaline molybdat. The precipitate requires from 500 to 600 parts of water to diſſolve it. The molybdat of mercury is decompoſed by the nitric acid.

The ſulphat, nitrat, and muriat of zink are not decompoſed by molybdic acid, but theſe ſalts are immediately decompoſed by the addition of an alkaline molybdat. The precipitate formed is extremely inſoluble in water. The molybdat of zink is decompoſed by ſulphuric, nitric, and muriatic acids.

A ſolution of antimony in tartaric acid is not decompoſed by an alkaline molybdat.

The ſolution of biſmuth in a mixture of ſulphuric and muriatic acids affords a citron yellow precipitate by the addition of an alkaline molybdat. This precipitate requires 500 parts of water for its ſolution. It is ſoluble alſo in nitric and muriatic acids, but may be again produced by diluting theſe acids with water.

The ſolution of cobalt in muriatic acid is not changed by molybdic acid, but it is completely decompoſed by an alkaline molybdat. The molybdat of cobalt, which is of a roſe colour, requires 100 parts of water for its ſolution. It is decompoſed by the ſulphuric, nitric, and muriatic acids.

A ſaturated ſolution of nickel in muriatic acid is decompoſed by an alkaline molybdat. The precipitate, which is of a white colour, approaching ſomewhat to an apple green, is extremely difficult of ſolution in water. Molybdat of nickel is decompoſed by ſulphuric, nitric, and muriatic acids.

A ſaturated ſolution of manganeſe is readily decompoſed by an alkaline molybdat. The molybdat of manganeſe is of a browniſh-white colour, and is ſoluble in from 40 to 50 times its weight of water. It is decompoſed by ſulphuric, nitric, and muriatic acids.

Sulphat and muriat of uranium are decompoſed only by the alkaline molybdat. The molybdat of uranium varies in its colour from a white to a yellow, and ſometimes to a brown. It is ſoluble in 100 parts of water, and is decompoſed by the ſulphuric, nitric, and muriatic acids. *Pelletier*, *Journ. de Phyſ.* Tom. XXVII. p. 434. *Iſlemann*, *Crell's An.* 1787, B. I. ſ. 407. *Heyer Crell's An.* 1787, B. II. ſ. 21, 124. *Klaproth's Beiträge*, B. II. ſ. 265.

CHAPTER VIII.

CONCERNING TUNGSTEN AND THE TUNGSTIC ACID.

THE mineral named *Tungsten* by the Swedes, and called *ponderous ſtone*, *lapis ponderoſus*, by ſeveral naturaliſts, and in particular by Bergman in his *Sciagraphia*, was conſidered by Cronſtedt as a ſpecies of iron ore, and diſtinguiſhed by him under this deſcription: *ferrum calciforme terrâ quâdam incognitâ intimè mixtum.* Moſt of the German naturaliſts arranged it among the ores of tin, under the name of *white tin crystals*, or *tin ſpar;* and in almoſt all collections of natural hiſtory, it was exhibited as belonging to that metal.

The accurate analyſis of this mineral was not attempted before Scheele; this chemiſt having examined this pretended tin ore, diſcovered by his experiments that it was compoſed of a peculiar acid united to lime. Bergman likewiſe found the ſame reſults by a connected ſeries of experimental inquiries. This diſcovery was made in the year 1781. The Swediſh chemiſts, from an examination of the properties of this mineral, were of opinion, that the acid which it contained was metallic.

Since this time Meſſrs. D'Elhuyar*, of the Royal Society of Biſcay, Mr. Angulo, of the Academy of Valladolid, and Mr. Crell, having repeated the experiments of the Swediſh chemiſts, and confirmed their reſults. After the definition we have given of this natural ſalt and its acid, we muſt obſerve that that which the Swedes called Tungſten is a ſalt formed by the tungſtic acid and lime. We adopt this name of tungſten for the ſemi-metal, which appears to be the baſe of this acid, and we ſhall call this ſpecies of mineral the native *tungstat of lime*.

Meſſrs. D'Elhuyar, of the Biſcayan Society, have diſcovered that *wolfram*, which was formerly conſidered as a poor ore of iron, is a combination of this acid of tungſten with mangaueſe and iron. They obtained a peculiar regulus from this ſemi-metal. The wolfram they uſed came from the tin mine of Zinwalde. It is in compreſſed hexahedral priſms; it has the metallic brilliancy, plated fracture, and may be cut with a knife. It contains in the quintal 22 parts of black oxyd of manganeſe, 12 of the oxyd of iron, 64 of the tungſtic acid, and 2 of quartz. The native tungſtat of lime from Schleckenwalde in Bohemia, contains, according to them, 68 parts of tungſtic acid, and 30 of lime.

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* The name is ſpelled De Luyartt in Cullen's tranſlation of their Analyſis of Wolfram, publiſhed in London in the year 1785.

These are the two known ores of the new ſemi-metal which we call tungſten. Meſſrs. D'Elhuyar fuſed 1 part of wolfram with 4 parts of the carbonat of potaſh; they lixiviated this mixture: the water diſſolved the tungſtat of potaſh, or combination of the alkali with the acid of tungſten, and they precipitated this acid in the form of a yellow powder, by the addition of nitric acid. This precipitate, urged by heat in a crucible with charcoal, afforded a metallic button compoſed of a number of ſmall friable globules. The following are the properties obſerved in this new ſemi-metal: a conſiderable ſpecific gravity, though never exceeding 17,9; very great infuſibility, which appears to exceed that of manganeſe; indiſſolubility in the three ſtrongeſt acids, and even in the nitro-muriatic acid; an eaſy union with ſome metals, particularly with iron and ſilver, whoſe properties it ſingularly alters; a facility of oxydation, by which it is converted into a yellow oxyd, which becomes blue by heat; it is indiſſoluble in acids, ſoluble in alkalis, remains ſuſpended in water by trituration, and reſembles an emulſion. Though ſome of theſe characters be analogous to thoſe of molybdena, as Bergman and Scheele had before ſhown in the molybdic acid, their union is nevertheleſs ſufficient to cauſe tungſten to be conſidered as a peculiar ſemi-metal. But many experiments are ſtill wanting for the exact determination of all its properties.

The chemiſts who have employed themſelves on this inquiry have made many more reſearches on the native tungſtat of lime, than on the ſemi-metal which Meſſrs. D'Elhuyar have obtained. In order to exhibit the whole of their diſcoveries on this mineral, it is neceſſary that we ſhould dwell for ſome time on its properties.

The tungſtat of native lime has been hitherto ſcarce; it is found in the iron mines of Bitzberg, in the tin mines of Schleckenwalde in Bohemia; and moſt of the white tin cryſtals of Sauberg near Ehrenfrienderſdorf, are tungſtat of lime: ſo that, by aſſaying the white tin cryſtals, preſerved in collections, by the methods we ſhall point out, it will be eaſy to diſcover ſome ſamples whoſe nature was not ſuſpected.

The tungſtat of lime is not ſenſibly altered by heat; it decrepitates, and is reduced to powder by the action of the blowpipe, but it does not melt. The blue flame colours it ſlightly, and nitre deprives it of this colour.

Boiling water has no action upon the powder of this metallic ſalt, and it is perfectly inſoluble. The action of the air, earths, the ſalino-terreſtrial ſubſtances, and the cauſtic alkalis upon this ſubſtance, are not known.

The ſulphuric acid, heated and diſtilled upon the native tungſtat of lime, comes over without alteration; the reſidue aſſumes a bluiſh colour; by waſhing with boiling water, a ſmall quantity of calcareous ſulphat is obtained, which proves that this ſubſtance contains lime, and that the ſulphuric acid decompoſes only a very ſmall portion.

Diluted nitric acid acts upon this ſalt by the aſſiſtance of heat, but without ſenſible efferveſcence. This acid gives it a yellow colour, which diſtinguiſhes it from the true ore of tin, and it decompoſes this ſubſtance by ſeizing its lime; about twelve parts of nitric acid in the ſtate of ordinary aqua-fortis are required for the complete decompoſition of one part of calcareous tungſtat. Scheele performed this operation at ſeveral repeated times. After the action of three parts of weak nitric acid upon one part of this neutral ſalt, he pours two parts of cauſtic ammoniac upon the powder, which the nitric acid had changed to a yellow colour. It becomes white by the action of the alkali; and he repeats this ſucceſſive action of the acid and the alkali, until the whole of the calcareous tungſtat is entirely diſſolved. From four ſcruples, treated in this manner, he had three grains of reſidue, which appeared to be ſiliceous. By precipitation from the nitric acid employed in this ſolution, by the addition of the pruſſiat of potaſh, and afterwards by potaſh itſelf, he obtained two grains of pruſſiat of iron or Pruſſian blue, and fifty-three grains of chalk; the ammoniac, by the addition of nitric acid, afforded an acid precipitate. In this experiment, the nitric acid decompoſes the calcareous tungſtat by ſeizing the lime; and the tungſtic acid, which is ſet at liberty by this decompoſition, is ſeized by the ammoniac. The ammoniacal ſalt formed by this laſt ſolution is decompoſed by the nitric acid, which has a ſtronger affinity with the ammoniac than this laſt has with the tungſtic acid. As this laſt acid is much leſs ſoluble than the ammoniacal tungſtat, it falls down, in proportion as it is ſet at liberty, in the form of a white powder. This powder is lixiviated with cold diſtilled water, in order to have the tungſtic acid in a ſtate of purity.

This acid may likewiſe be obtained by another proceſs, which Scheele employed with equal ſucceſs. One part of native calcareous tungſtat in powder is fuſed in an iron crucible, with four parts of carbonat of potaſh; this maſs is lixiviated with twelve parts of boiling water, and nitric acid is poured on until there be no more effervefcence. It is fuſed a ſecond time with four parts of carbonat of potaſh, waſhed with water, and treated with nitric acid till the effervefcence ceaſes entirely; at which time there remains only a ſmall portion of ſilex, and all the tungſten is decompoſed. In fact, during the fuſion the potaſh ſeizes the tungſtic acid, with which it forms a peculiar neutral ſalt, while the carbonic acid unites to the lime, which it changes into chalk. When the melted maſs is lixiviated, the water diſſolves the tungſtat of potaſh, which is much more ſoluble than the chalk, which remains alone; the nitric acid, employed afterwards, diſſolves the chalk with effervefcence, without affecting that portion of calcareous tungſtat which the firſt four parts of alkali did not decompoſe. At the ſecond operation, the ſalt being completely decompoſed by the other four parts of carbonat of potaſh, the nitric acid ſeizes all the chalk; ſo that, by the aſſiſtance of eight parts of fixed alkali and a ſmall quantity of aqua-fortis, ſucceſſively employed, the principles of calcareous tungſtat are entirely ſeparated; its acid is united with the potaſh, and its lime combined with the nitric acid. By precipitating the calcareous nitrat by potaſh, the quantity of lime contained in the calcareous tungſtat made uſe of comes to be known; and nothing more remains to be done but to ſeparate the tungſtic acid which is united to the fixed alkali. For this purpoſe, the proceſs deſcribed in the firſt experiment is made uſe of. A ſufficient quantity of nitric acid is poured into the lixivium of the melted mixture of tungſtat of lime with the carbonat of potaſh; this lixivium becomes turbid and thick, becauſe the nitric acid having a ſtronger affinity with the fixed alkali than the tungſtic acid has, this laſt is precipitated in powder, and the liquor holds nitre in ſolution. The precipitate is then to be waſhed with cold water, and affords the pure tungſtic acid in the form of a white powder, as in the firſt operation. This proceſs is even preferable to the other, becauſe more eaſy and leſs expenſive [a].

The muriatic acid acts upon calcareous tungſtat in the ſame manner as the nitric acid does, and decompoſes it with the ſame energy; and, as it produces a deeper yellow colour, Bergman recommends it for aſſaying and diſtinguiſhing this earthy ſalt.

The tungſtic acid obtained by either of theſe three proceſſes has, as we obſerved, the form of a white powder. By the blow-pipe it becomes yellow, brown, and black, without melting or volatilizing. It is ſoluble in twenty parts of boiling water; the ſolution has an acid taſte, and reddens the tincture of turnſole [b].

The tungſtic acid appears to form with barytes a ſalt abſolutely inſoluble in water; and with magneſia, another ſalt of difficult ſolution.

When its ſolution is poured into lime water, it produces a ſmall precipitate, which is greatly increaſed by heat, and conſiſts of regenerated calcareous tungſtat, according to Scheele [c].

The tungſtic acid ſaturated with potaſh affords a ſalt which falls down in very ſmall cryſtals, whoſe form has not yet been determined [d]. Scheele does not ſpeak of its combination with ſoda. According to him, it forms with ammoniac a ſalt in the form of very ſmall needles: this ammoniacal tungſtat, when expoſed to heat in a retort, lets the ammoniac eſcape, and the tungſtic acid remains in the form of a dry yellowiſh powder: the ſame ſalt decompoſes calcareous nitrat, and again forms the tungſtat of lime [e].

The tungſtic acid, heated with the ſulphuric acid, aſſumes a bluiſh colour; with the nitric and muriatic acids, it becomes a lemon yellow; with alkaline ſulphure, it affords a green precipitate. Scheele has not determined the cauſe of theſe changes of colour.

This chemiſt having obſerved, that the tungſtic acid readily becomes coloured by combuſtible ſubſtances, and itſelf gives a blue colour to vitreous fluxes, ſuch as borax, &c. heated this acid in a crucible with lintſeed oil; but he did not obtain metal, and the acid was only blackened. Bergman, however, was of opinion, from the conſiderable ſpecific gravity of this acid, its coloration by inflammable bodies, and its precipitation by the pruſſiat of potaſh, or Pruſſian alkali, that it is of metallic origin. We have already mentioned the proceſs by which Meſſrs. d'Elhuyar ſucceeded in reducing the tungſtic oxyd obtained from wolfram into metallic globules, and the metallic nature of this acid is no longer a problem [f].

NOTES ON CHAPTER VIII.

TUNGSTEN.

[a] RICHTER has propoſed a different method of preparing this acid. Two parts of wolfram, finely pulverized, are to be mixed with ſeven parts of pure nitrat of potaſh. A quantity of this mixture, ſufficient to fill one third of the crucible uſed, is to be expoſed in it to a gradually increaſed heat till it fuſes. It is then to be poured out on a tile which has been previouſly greaſed, or on a copper plate. This maſs is to be pulverized when cold, and agitated in ſix times its own quantity of water. After having been kept warm for ſome hours, and frequently ſtirred, it is to be filtered. Sulphuric acid is then to be added to the filtered liquor ſo long as it continues to afford a white precipitate. This precipitate, which is the tungſtic acid, is to be waſhed and dried.

[b] Klaproth, in the memoir formerly quoted, remarks, that this is true of the acid only when recently prepared and moiſt; for, after it had been completely dried, not leſs than 150 parts of water were required for its ſolution. The taſte of this ſolution, he alſo remarks, is rather diſagreeably metallic than acid.

[c] It occaſions alſo an immediate precipitation in the muriatic ſolutions of lime and barytes. Tungſtic acid has no effect on the ſolutions of iron and copper in acids, but it precipitates ſilver, mercury, lead, and tin. With ſolutions of alkaline ſulphures it gives blue precipitates. *Gren's Handbuck der Chemie, Wolfram-metal.*

[d] This ſalt is ſaid to contain at all times an exceſs of alkali. It is decompoſed by the nitric acid.

[e] It is the acid in this ſalt that ſeems to be in exceſs, for the ſolution gives a red colour to paper tinged with litmus. Tungſtat of ammoniac decompoſes the ſulphats of iron, copper, zink and alumine, muriat of mercury, and the acetats of lead and copper. With lime water it produces tungſtat of lime. It is decompoſed by ſulphuric, nitric, and muriatic acids. The precipitate by the firſt acid is of a blue, that by the two latter, of a yellow colour. Pruſſiat of alkali occaſions no precipitation. According to Pelletier, muriat of tin takes a portion of oxygen from the tungſtic acid. *Pelletier Ann. de Chem.* T. XII. p. 232.

Morveau has lately diſcovered that the tungſtic oxyd renders vegetable colours ſo fixed as not to be acted on even by the oxygenated muriatic acid.

[f] Scheele, Bergman, and Gmelin, did not ſucceed in their attempts to procure this ſubſtance in its metallic ſtate. Klaproth tried to reduce the yellow oxyd with a variety of combuſtible ſubſtances, but without ſucceſs. *Klaproth*, *Crell's Annal.* 1786, B. II. ſ. 502. *Gmelin*, do. do. ſ. 3, 114.

Ruprecht and Tondy ſay they have obtained this metal, by uſing combuſtible ſubſtances alone, and by a mixture of combuſtible and alkaline ſubſtances. *Annal. de Chem.* Tom. VIII. p. 4.

The following proceſs is recommended by Richter. Equal parts of tungſtic acid and dried blood are to be expoſed for ſome time to a red heat. The black powder which is formed is to be preſſed into another ſmaller crucible, and expoſed again to a violent heat for at leaſt an hour. Tungſten will then, according to Richter, be found in the crucible in its metallic ſtate. This author very properly objects to the uſe of alkalis, or alkaline ſalts, in this proceſs, as they are apt to form neutral ſalts with the tungſtic acid, and in this way to prevent its reduction. From the facility, however, with which Ruprecht and Richter ſeem to have obtained this metal, it may fairly be queſtioned whether it was entirely free of all admixture. *Richter Ueber die Neu. Gegenſtände der Chem. Stuck.* I. ſ. 49.

For a farther account of this acid the reader may conſult *Scheele's Chemical Eſſays, Bergman's Opuſcula, Keir's Chemical Dictionary, and the Chemical Analyſis of Wolfram, by Don Joſeph and Don Fauſto de Luyart.*

CHAPTER IX.

CONCERNING COBALT.

Cobalt, or cobolt, is a metal of a reddiſh-white colour, and cloſe grain, ſo brittle as to be eaſily reduced into powder by the peſtle. Weighed in water, it loſes about the eighth of its weight; its ſpecific gravity is about 7,700, according to Bergman [a]. It cryſtallizes in aggregates of needles placed one on the other [b].

Cobalt has never been found pure and native, but it is almoſt always calcined and united with arſenic, the arſenic acid, ſulphur, iron, &c. The following are the principal ores of cobalt, diſtinguiſhed, according to their component parts, by Bergman and Mongez.

1. Native cobalt, combined with arſenic. This ore is ſolid, grey, ponderous, has little brilliancy, and is granulated in its fracture. It gives ſparks with ſteel, and becomes black in the fire. The nitric acid diſſolves it with effervefcence; and it forms a ſympathetic ink with the muriatic acid.

2. Cobalt in the ſtate of an oxyd. This ore, which appears to conſiſt of cobalt oxydated by an acid, is uſually of a blackiſh grey, ſometimes ſimilar to lamp-black, often friable and pulverulent; it ſoils the fingers. When compact, its fracture preſents roſe-coloured ſpots; it ſometimes reſembles ſcoriæ of glaſs, whence it has been called *vitreous ore* of cobalt by ſome naturaliſts. This ore does not contain arſenic when it is pure, but is frequently mixed with martial ochre.

3. Cobalt united to the carbonic acid: *flowers of cobalt, red, roſe-coloured, or the colour of peach bloſſoms.* The arſenical acid diſcovered in it by Bergman and Mongez give it this colour. This ore is either in maſſes, in powder, in a ſtriated efflorefcence, or in four-ſided priſms, with ſummits of two faces. Its colour is deſtroyed by fire, in proportion as the arſenic acid is diſſipated.

4. Cobalt united to iron and ſulphuric acid: *ſpecular ore of cobalt;* it is very improperly called *ſulphureous cobalt,* ſince

it does not contain ſulphur, but a ſmall proportion of ſulphuric acid. This ore is white, or grey, and very brilliant. It is the richeſt of any, and often gives fire with ſteel.

5. Cobalt united to ſulphur, arſenic, and iron. This mineral is called *white or grey cobalt ore.* It is of a whitiſh grey, cryſtallized in cubes, either entire or truncated, ſo as to form ſolids of fourteen, eighteen, or twenty-ſix facets. Its fracture is lamellated and ſpathoſe; it ſometimes has dendrites on its ſurface, reſembling fern; in this ſtate it is called *knit cobalt.* The white ores of cobalt are frequently without any regular cryſtallization; but they are always known by their whitiſh grey colour, their weight, which is leſs than that of the preceding ores, and by the red efflorefcence they almoſt always have on their ſurface.

To aſſay cobalt ore, it is pounded, waſhed, and afterwards roaſted, to diſſipate the arſenic. The cobalt remains in a ſtate of black oxyd, more or leſs deep with reſpect to colour; this is mixed with three parts of *black flux*, and a ſmall quantity of decrepitated marine ſalt; the fuſion is performed by a forge heat in a covered crucible, which muſt be ſlightly agitated to precipitate the metal as ſoon as the fuſion is complete. The metallic button is ſometimes found to conſiſt of two diſtinct ſubſtances, cobalt being uppermoſt, and biſmuth beneath; a ſtroke of the hammer readily ſeparates them.

Modern mineralogiſts, eſpecially Bergman and Kirwan, propoſe to aſſay cobalt ores by the nitric acid. The cobalt and the iron are by this means diſſolved, and are precipitated by the addition of carbonat of ſoda; the cobaltic precipitate is to be afterwards diſſolved by the acetous acid. Scheffer adviſes trying the colouring quality of cobalt ores, by fuſion with three parts of potaſh, and five of powdered glaſs.

In the large works, cobalt is not extracted in the metallic form: after pounding and waſhing the cobalt ore, it is roaſted in a furnace, which terminates in a long horizontal flue, that ſerves inſtead of a chimney. In this flue, the oxyd of arſenic being ſublimed, becomes condenſed into the ſemi-vitrified ſubſtance, which is improperly called *white arſenic.* If the ore contain biſmuth, this very fuſible metal is collected at the bottom of the furnace; the cobalt remains in the ſtate of an obſcure grey oxyd, called *zaffre.* The zaffre, in commerce, is never pure, but is mixed with three times its weight of pulverized flints. In this ſtate, if it be expoſed to a ſtrong fire, it melts into a glaſs, of a dark blue colour, called *ſmalt.* This is reduced to powder in mills, and mixed with water. The firſt portion which falls down is the largeſt grained, and is called *coarſe ſmalt*; the turbid water being decanted off, affords a ſecond precipitate; and this decantation is repeated four times in the whole: the laſt depoſition, which is finer than the reſt, is improperly called *azure of four fires.* This azure is uſed in many arts to give a blue colour to metals, glaſſes, &c.

The zaffre of commerce, fuſed with three times its weight of black flux, a ſmall quantity of tallow and marine ſalt, affords the ſemi-metal, known by the improper name of *regulus of cobalt.* The reduction of zaffre is very difficult. A large quantity of flux muſt be uſed, and the crucible muſt be kept a conſiderable time in a white-red heat, that the matter may become very fluid, and that the ſcoria may be completely fuſed into a blue glaſs; at this period the cobalt ſinks to the bottom, in the form of a button.

Cobalt, expoſed to heat, does not melt till it is well ignited. This metal appears to be very fixed in the fire, and it is not known whether it can be volatilized in cloſe veſſels. If it be ſuffered to cool ſlowly it cryſtallizes in needle-formed priſms, placed one on the other, and united in bundles. It conſiderably reſembles maſſes of baſaltes, which are ſeparated from each other, as Mongez obſerves. To ſucceed in this cryſtallization, the cobalt muſt be melted in a crucible till it appears to boil; and when the ſurface of the ſemi-metal becomes fixed on withdrawing it from the fire, the veſſel is to be inclined. The metal, which ſtill remains fluid, runs out; and that portion which adheres to the ſides of the kind of geodes, formed by the cooling of the ſurface of the cobalt, is found to be covered with cryſtals.

Cobalt, melted and expoſed to the air, becomes covered with a dull pellicle, which is an oxyd of the ſemi-metal, formed by its combination with oxygen. A larger quantity of the oxyd of cobalt may be more eaſily had, by expoſing the pulverized ſemi-metal, in a ſhallow veſſel, under the muffle of a cuppelling furnace, and ſtirring it up, from time to time, to renew the calcining ſurface. This powder, after remaining ignited for ſome time, loſes its brilliancy, increaſes in weight, and becomes black. This black oxyd requires a moſt violent heat to convert it into glaſs, which is then of a deep blue colour.

Cobalt becomes ſlightly tarniſhed by expoſure to air, and is not attacked by water. It does not unite with earths, but its oxyd combines with them, by fuſion, and forms a beautiful blue glaſs, extremely fixed in the fire. This property of the oxyd of cobalt renders it of the greateſt uſe in the art of painting in enamel, on porcelain, &c.

The action of barytes, magneſia, and lime on cobalt is not known. Alkalis diſſolved in water manifeſtly alter it; but theſe changes have not been accurately deſcribed[c].

This metal diſſolves in all the acids, but with different phenomena, according to its own ſtate and that of the acid.

Cobalt, in the metallic ſtate, is not ſoluble in ſulphuric acid, unleſs it be concentrated and boiled. This ſolution is made in a glaſs phial, or retort; when the acid is almoſt entirely evaporated, in the form of ſulphureous gas, the reſidue muſt be waſhed; a portion diſſolves in the water, and communicates a roſy or greeniſh colour; it is the ſulphat of cobalt. The other part conſiſts of cobalt, oxydated by the acid, whoſe oxygen has combined with the metal. Baumé affirms, that by ſufficiently evaporating the ſulphuric ſolution of cobalt, two ſorts of cryſtals are obtained by cooling; the one white, ſmall, and cubical; the other greeniſh, quadrangular, ſix lines in length, and four in breadth. He conſiders theſe laſt as the ſulphat of cobalt. The former are produced by certain foreign matters united to the cobalt. The cryſtals of the ſulphat of cobalt moſt commonly obtained have the form of ſmall needles, deſcribed by Sage as tetrahedral-rhomboidal priſms, terminated by a dihedral ſummit, with rhombic faces. They are decompoſable by fire, and leave an oxyd of cobalt, not reducible alone. Barytes, magneſia, lime, and the three alkalis, likewiſe decompoſe this ſalt, and precipitate a roſe coloured oxyd of cobalt. 100 grains of cobalt, diſſolved in the ſulphuric acid, afford, by the addition of pure ſoda, about 140 grains of precipitate; and by carbonat of ſoda, 160 grains. This augmentation depends on the oxygen of the ſulphuric acid, which is united to the cobalt; and in the ſecond caſe, likewiſe on the carbonic acid, which combines with the oxyd of cobalt. The ſulphuric acid, diluted with water, acts on zaffre, and diſſolves a portion, with which it forms ſulphat of cobalt [d].

The nitric acid diſſolves cobalt, with effervеſcence, by the aſſiſtance of a gentle heat; nitrous gas is diſengaged, in proportion as the oxygenous principle of the acid unites with the cobalt. When the ſolution is nearly ſaturated, it is either of a roſy brown, or bright green colour. By a ſtrong evaporation, it affords nitrat of cobalt, in ſmall needles, joined together. This ſalt is very deliqueſcent, boils up on hot coals, without detonating, and leaves a deep red oxyd. It is decompoſed by the ſame ſaline intermediums as the ſulphat of cobalt. If more alkali be added in theſe decompoſitions than is neceſſary to precipitate the oxyd of cobalt, the precipitate diſappears, by ſolution in the exceſs of alkali [e].

The muriatic acid does not diſſolve cobalt in the cold, but takes up a portion by the aſſiſtance of heat. This acid acts more ſtrongly on oxyd, forming a ſolution of a red brown, which becomes green when heated. By evaporation, it affords a muriat of cobalt cryſtallized in ſmall needles, very deliqueſcent, which becomes green when heated, and is ſoon after decompoſed [f].

Aqua regia, or nitro-muriatic acid, diſſolves cobalt rather more eaſily than the muriatic, but leſs ſo than the nitric acid. This ſolution has been long known as a *ſympathetic ink*, which is not viſible unleſs heated, in which caſe it becomes of a beautiful ſea-green, that diſappears in proportion as the paper becomes cold. This property belongs to the ſolution of the oxyd of cobalt in the muriatic acid; and the nitric acid of the aqua regia only facilitates its ſolution and ſuſpenſion. It was formerly thought, that the green colour, produced by heat in the ſympathetic ink of cobalt, aroſe from the metallic ſalt being cryſtallized, and afterwards attracting a ſufficient quantity of water from the cold air to diſſolve it, and cauſe it to diſappear entirely; but it is proved, that the muriat of cobalt, diſſolved in water, aſſumes the ſame colour when expoſed to a certain degree of heat [g].

The boracic acid does not diſſolve cobalt immediately; but when a ſolution of borat of ſoda is mixed with a ſolution of the metal, in one of the foregoing acids, a double decompoſition takes place. The ſoda unites with the acid which held the metallic oxyd in ſolution, and the oxyd combining with the boracic acid forms a precipitate, difficult of ſolution, and which may be ſeparated by filtration [h].

Cobalt has no action on moſt of the neutral ſalts. Heated with nitre, it is oxydated. If a mixture of one part of cobalt, in powder, and two or three parts of dry nitre, be thrown into a red-hot crucible, a ſtrong detonation does not follow, but ſmall ſcintillations are very evidently ſeen. A portion of the cobalt is found, converted into an oxyd of a red colour, more or leſs deep, and ſometimes of a green. This experiment, as well as many others, relating to the detonation of nitre with metallic ſubſtances, deſerves to be more particularly attended to.

Cobalt does not decompoſe muriat of ammoniac. Bucquet, who made this experiment with great care, did not obtain a particle of ammoniac, a circumſtance which no doubt depends on the ſmall degree of affinity which exiſts between this metal and the muriatic acid.

The action of hydrogen gas on cobalt is not known. Sulphur unites very difficultly with this ſubſtance; alkaline ſulphures favour this combination, and produce a kind of artificial ore, of a finer or cloſer grain, and of a whiter or yellower colour, in proportion to the quantity of ſulphur in the combination. Baumé, who has given an excellent account of this compound, in the ſecond volume of his Chemiſtry, (Vol. II. p. 228 to 279), obſerves, that it is not decompoſable by acid, and that fire is not capable of ſeparating all the ſulphur [i].

Cobalt is not uſed in its metallic ſtate; its oxyd, as we have obſerved, is applied to give a blue colour to glaſs, enamel, pottery, and other ſubſtances of the like nature. It forms alſo a ſypathetic ink.

NOTES ON CHAPTER IX.

COBALT.

[a] TASSAERT found the ſpecific gravity of cobalt to be 8,5384. *Ann. de Chem.* Tom. XXVIII. p. 92.

[b] Cobalt is not only attracted by the magnet, but, if we may truſt to the accuracy of ſome experiments made by Kohl and Wenzel, it is alſo magnetic. *Crell's Neu. Entdeck.* Th. VII. ſ. 39.

[c] Ammoniac, both in the mild and cauſtic ſtate, diſſolves the oxyd of cobalt. This ſolution, which is of a blue in a high, becomes of an amethyſtine colour in a low temperature.

[d] Cryſtals of ſulphat of cobalt require for their ſolution twenty-four parts of water at the temperature of 144° of Fahrenheit. They are inſoluble in ſpirit of wine, effloreſce in the air, and become ſoluble by heat in their water of cryſtallization. When expoſed to an immenſe heat the ſulphuric acid is diſſipated, and black oxyd of cobalt remains in the retort. *Gren's Handbuck, Kobalt.*

[e] Nitrat of cobalt is decompoſed by ſulphuric acid.

[f] Bergman remarks that the muriatic acid has a greater attraction for cobalt than either the nitric or ſulphuric acids; for when ſulphat of cobalt is diſſolved in muriatic acid, and the liquor concentrated, the addition of ſpirit of wine does not occaſion any precipitation which it muſt have done had the liquor contained any ſulphat of cobalt. *Bergman Opuſc.* Vol. III. p. 462.

[g] Sympathetic ink is moſt eaſily prepared by diſſolving one part of cobalt, or its oxyd, in three of aqua fortis. After diluting this ſolution with twenty-four parts of water, and filtering it, one part of muriat of ſoda, or of ammoniac, is to be added, and the ſolution filtered anew. Letters made with this ink become viſible by encloſing them in cloſe veſſels with quicklime, or with ſulphuric acid.

[h] Fluoric acid has no action on cobalt, either in a high or low temperature, but it diſſolves readily the oxyd. The ſolution, which is of a yellow colour, does not cryſtallize according to Scheele. The properties of this compound have been but little inveſtigated.

Phoſphoric acid diſſolves the oxyd of cobalt by the aſſiſtance of heat, and forms with it a dark wine-coloured ſolution. In the dry way phoſphoric acid melts with the oxyd of cobalt into a beautiful blue glaſs.

The ſolution of oxyd of cobalt in tartaric acid is of a pale red colour, and cryſtallizable.

Oxalic acid, according to Bergman, diſſolves cobalt and its oxyd even without the aſſiſtance of heat, and forms with it a roſe coloured powder, which is very inſoluble in water. This ſalt becomes ſoluble by an exceſs of acid, and cryſtallizes by evaporation. It forms ſympathetic ink with muriat of ſoda. Oxalic acid, however, takes oxyd of cobalt from all the other acids.

Acetic acid diſſolves oxyd of cobalt by long digeſtion or boiling. The ſolution is of a roſe red colour, and affords a violet coloured deliqueſcent ſaline maſs. Iſſemann has diſcovered a method of obtaining a beautiful blue ſympathetic ink, from the acetat of cobalt. For this purpoſe he boiled one part of the oxyd of cobalt in ſixteen of diſtilled acetic acid, till four parts of the acid only remained. He filtered this ſolution, and evaporated ſtill about one half of it. He then added a quantity of muriat of ſoda, equal to the fourth part of the cobalt employed, and diſſolved the muriat by the aſſiſtance of heat. Letters written with this ink have a beautiful blue colour in the heat, but diſappear in the cold. *Crell's Ann.* 1785, B. II. ſ. 25, 130.

Arſenic acid diſſolves readily the oxyd of cobalt. The ſaturated combination of this ſalt is inſoluble in water, but it becomes ſoluble by an exceſs of acid. Arſenic acid cannot be ſeparated from this combination by heat alone; but this effect is eaſily produced by the addition of charcoal.

The combination of carbonic acid with cobalt may be inferred from the effects of the carbonats of alkali on the acid combinations of cobalt; but it ſeems to be yet undetermined whether water, impregnated with carbonic acid, be capable of diſſolving that ſubſtance.

Pruſſiat of alkali precipitates cobalt from its acid ſolutions of a reddiſh blue colour. This precipitate is inſoluble in acids, and in an exceſs of pruſſiat of alkali.

Gallic acid precipitates cobalt of a blue colour, but this combination is but little known. The ſame thing is true of the citrat, malat, and ſuccinat of cobalt.

i Phoſphorus unites eaſily with cobalt. The phoſphure of cobalt, which is of a bluiſh white colour and brittle conſiſtence, exhibits no phoſphoreſcence in the air.

Cobalt unites by fuſion with gold; but the properties of the mixture are little known. It precipitates gold from its ſolution in aqua regia.

Cobalt melts with platina, and precipitates it alſo from its ſolution in aqua regia.

Silver does not unite by fuſion with cobalt. The ſolution of ſilver in nitric acid is precipitated by cobalt, 37 parts of cobalt only being required to precipitate 100 of ſilver.

Mercury does not appear to amalgamate with cobalt. It is precipitated from nitric acid by cobalt in its metallic ſtate.

Lead, according to Gmelin, unites by fuſion with cobalt, and is precipitated by this metal from its ſolution in acids.

Biſmuth does not unite by fuſion with cobalt. It alſo is precipitated by the cobalt from its ſolutions in acids.

Nickel unites readily by fuſion with cobalt, and is ſeparated from it with great difficulty. This ſeparation is effected by melting it with a ſulphure of potaſh, which diſſolves the cobalt more eaſily than the nickel. The affinity of theſe two metals for acids has not been determined, though there is reaſon to think that the affinity of the cobalt is ſtrongeſt. When a bit of nickel is introduced into a ſolution of nitrat of cobalt, a change in the colour is produced, but without any evident precipitation of cobalt.

Copper melts with cobalt. They may be ſeparated by ſublimation with muriat of ammoniac. Copper is precipitated from its ſolution in acids by cobalt. From a ſolution of copper and cobalt in aqua regia, the copper may be precipitated by zink, which produces no change in the ſolution of cobalt.

Arſenic and its oxyd unite with cobalt. They may be ſeparated by roaſting them with charcoal. The arſenic does not precipitate cobalt from acids, though it ſeems to have a greater affinity with theſe ſubſtances than cobalt.

Iron melts eaſily with cobalt. Neither of theſe metals ſeem to precipitate the other from its ſolution in acids.

Tin produces a ſlight precipitation from muriat of cobalt. See *Gren's Handbuck, Kobalt. Gmelin, Ann. de Chem.* T. XIX. p. 357.

CHAPTER X.

OF BISMUTH.

Bismuth, or *tin glaſs*, is a brittle metal, of a yellowiſh white, very ponderous, and diſpoſed in large plates. It ſcarcely yields at all to the ſtrokes of the hammer without breaking into ſmall brilliant pieces, and may even be beat into powder. By immerſion in water it loſes about 1-10th of its weight. It is ſuſceptible of cryſtallization, in the form of polygonal priſms, which are diſpoſed in quadrangular ſolids, perfectly ſimilar to thoſe of muriat of ſoda. It has ſcarcely any ſmell or taſte.

Biſmuth is often found native. It is known by its yellowiſh brilliant colour; its ſoftneſs, or yielding to the knife; its laminated texture when broken; and, more eſpecially, by its very great fuſibility. It is ordinarily cryſtallized in triangular laminæ, which are placed one over the other ſlantwiſe. There are ſpecimens of this ſemi-metal, in the form of very regular octahedrons; its gangue is commonly quartzoſe. It is found at Scala, in Neritia, in Dalecarlia, and at Schneeberg in Germany.

Many modern mineralogiſts doubt the exiſtence of the arſenical ore of biſmuth. Some of them however affirm that this ore is chatoyant, and commonly diſpoſed in ſmall glittering laminæ of a bright grey colour. It is likewiſe, according to theſe authors, almoſt always mixed with native biſmuth and cobalt, whoſe reddiſh efflоreſcence is obſervable on the ſurface of the ſpecimens.

The ſulphureous ore of biſmuth, or native ſulphure of biſmuth, is of a whitiſh grey, inclining to blue, with pointed facets, or acute priſms; it has the brilliancy and colour of lead ore, or galena, and almoſt always exhibits ſquare facets; but it is never found in fragments truly cubical. It may be cut with a knife. It is very rare, and is found at Baſtnas in Sweden, and at Schneeberg in Saxony.

Cronſtedt likewiſe ſpeaks of a martial ore of biſmuth, which he ſays is found in large cuneiform ſcales at Konſberg in Norway.

Laſtly, Biſmuth is ſometimes met with in the ſtate of an oxyd. This is in the form of a granulated effloreſcence, of a greeniſh yellow, and never of a red colour, on the ſurface of ores of biſmuth. Mr. Kirwan thinks that the oxyd of biſmuth is united with the carbonic acid. Some mineralogiſts affirm, that the native ſulphat of biſmuth is mixed with this oxyd.

To make an aſſay of the ore of biſmuth, it is uſually reckoned ſufficient to expoſe it to a low degree of heat in a crucible, together with a certain quantity of reducing flux. As biſmuth is volatile, the fuſion ſhould be made as quickly as poſſible; it would indeed be better to make this aſſay in cloſe veſſels, as Cramer recommended.

The ſmelting of biſmuth in the large way is not attended with more difficulty. A cavity is made in the earth, which is covered with billets of wood placed one on the other; the wood is ſet on fire, and the ore being broken ſmall, is thrown in it. The biſmuth melts, and runs into the cavity, where it takes an orbicular form. In other places the trunk of a pine tree, hollowed into the form of a gutter, is placed in the earth in an inclined poſition, and wood laid over it; the biſmuth is thrown on this combuſtible matter after it is ſet on fire: the ſemi-metal melts, falls into the channel, which conducts it into a cavity made in the earth, over which the extremity of the trunk is placed. The biſmuth, thus obtained, is poured into iron moulds.

Biſmuth is ſcarcely at all altered by the contact of light. It is extremely fuſible, and melts long before the red heat commences. In cloſed veſſels it ſublimes without alteration; if it be permitted to cool ſlowly, it cryſtallizes in Greek volutes; it cryſtallizes the moſt eaſily of any metallic ſubſtance. Brongniart is the firſt chemiſt who perfectly ſucceeded in producing this cryſtallization.

If biſmuth be kept in fuſion with contact of air, its ſurface becomes covered with a pellicle, which changes into an oxyd of a greeniſh grey, or brown, named Aſhes or Calx of Biſmuth. Nineteen drachms of biſmuth calcined in a capſule of glaſs, afforded Baumé twenty drachms thirty-four grains of oxyd.

Biſmuth heated to redneſs, burns with a ſmall blue flame, ſcarcely ſenſible. Its oxyd evaporates in the form of a yellowiſh ſmoke, which condenſes on the ſurface of cold bodies, into a powder of the ſame colour, improperly called *flowers of biſmuth*. This powder owes its volatilization only to the rapidity with which the biſmuth burns; for if it be expoſed alone to fire it melts into a greeniſh glaſs, without ſubliming. Geoffroy the younger obſerved, that the oxyd of biſmuth, which riſes the laſt, is of a beautiful yellow, reſembling orpiment.

The grey or brown oxyds, the yellow flowers, and the glaſs, are nothing more than combinations of this metal, with the baſe of vital air, or of oxygen. They are not reducible without addition, becauſe the adheſion between the two principles which compoſe them is very conſiderable; but carbon, hydrogen gas, and all organic combuſtible matters, which contain either of theſe two ſubſtances, are capable of decompoſing them, and reſtoring their metallic ſtate, by ſeizing the oxygen, with which theſe bodies have more affinity than biſmuth.

D'Arcet having expoſed biſmuth in a ball of unbaked porcelain, to the heat of the furnace in which that ſubſtance is uſually baked, part of the metal flowed out through a crack; the portion, which remained in the veſſel formed a glaſs of a dirty violet colour, while the biſmuth, melted in communication with the external air, was yellowiſh. From this fact, and many others of a like nature, it appears that glaſſes made with or without the contact of air are different from each other.

Biſmuth becomes tarniſhed a little by expoſure to the air, whitiſh ruſt being formed on its ſurface. It is not attacked by water, neither does it combine with earths; but its oxyd unites with all earthy matters, and facilitates their fuſion: it gives a greeniſh yellow tinge to glaſſes into which it enters.

The action of the ſalino-terreſtrial ſubſtances and alkalis on this ſemi-metal, are not yet known.

Concentrated and boiling ſulphuric acid acts on biſmuth, the acid is partly decompoſed, and ſulphureous gas is exhaled. The maſs remaining in the veſſel, after the decompoſition of a part of the acid, is white; that portion which is in the ſaline ſtate may be ſeparated by means of water, from the other portion which is oxydated, and does not contain any acid; the lixivium, by evaporation, affords a ſulphat of biſmuth in ſmall deliqueſcent needles. This ſalt is decompoſable by fire, by the ſalino-terreſtrial ſubſtances, by alkalis, and even by water alone, in large quantities. The ſulphite of biſmuth is not known.

The nitric acid diſſolves biſmuth with an aſtoniſhing rapidity; or rather this metal decompoſes the acid, and very quickly takes from it a part of its oxygen; the mixture becomes very ſtrongly heated, and emits denſe red vapours. If the combination be made in the pneumato-chemical apparatus, a large quantity of nitrous gas is obtained; and this proceſs is one of the readieſt and moſt convenient for procuring this gas. During the ſolution, a black powder is precipitated, which Lemery ſuppoſed to be bitumen, and Pot conſidered as calcined oxyd of biſmuth; Baumé ſuſpected it to be ſulphur; perhaps it may be charcoal.

The nitric ſolution of biſmuth is without colour, and when it is much ſaturated, it affords cryſtals without evaporation. Evaporation, and cooling, afford a nitrat of biſmuth, concerning the form of which chemiſts differ. Baumé affirms, that this ſalt is diſpoſed in large needles, pointed at one end. Sage aſſerts, that the cryſtals are tetrahedral priſms, a little flattened and terminated by two obtuſe trihedral pyramids, whoſe planes make one rhombus and two trapeziums. By a ſlow evaporation, I have obtained flattened rhomboids, very large, and perfectly ſimilar to the calcareous ſpar of Iceland.

The nitrat of biſmuth detonates feebly, and with reddiſh ſcintillations, after which it melts and ſwells up, leaving an oxyd of a greeniſh yellow, not reducible without addition. This ſalt expoſed to air, loſes its tranſparency, at the ſame time that the water of cryſtallization is diſſipated. If water be added, inſtead of diſſolving it, the fluid becomes white, milky, and an oxyd of biſmuth is precipitated.

The ſame thing happens, if the nitric ſolution of biſmuth be poured into water, the greateſt part of the oxyd of this metal being precipitated under the form of a white powder, called *magiſtery* of biſmuth. One hundred grains of this metal, diſſolved in the nitric acid, afford one hundred and thirteen grains of precipitated oxyd, by reaſon of the oxygen with which it combines [a]. A large quantity of water muſt be uſed, if the precipitate be deſired very white and fine. It is uſed as a pigment for rendering the ſkin white, but it has the inconvenience of becoming black when in contact with odoriferous or combuſtible matters. This property is more evident in this than in moſt of the metallic oxyds. Though nitrat of biſmuth be in a great meaſure decompoſed by water, a portion nevertheleſs remains diſſolved, which cannot be precipitated, but by lime or alkalis. The character of being precipitated by water is common to all the ſolutions of biſmuth. The nitrit of biſmuth is not known.

The muriatic acid acts with difficulty on this metal. It is neceſſary that the acid ſhould be very concentrated, and be kept in digeſtion on the biſmuth for a long time; the ſolution ſucceeds ſtill better, when a large quantity of muriatic acid is diſtilled from the metal. The mixture has a fetid ſmell; the reſidue is to be waſhed with water, which becomes charged with a portion of the metallic oxyd united to the acid. The muriat of biſmuth cryſtallizes with difficulty; it may be ſublimed into a kind of ſoft ſalt, improperly called *butter of biſmuth;* it ſtrongly attracts the humidity of the air; and, laſtly, water decompoſes it, and precipitates it in the form of a white oxyd.

The action of the other mineral acids on biſmuth is not known [b].

Biſmuth is oxydated by nitre, but without any ſenſible detonation; this ſemi-metal does not decompoſe ammoniacal muriat, but its oxyd completely ſeparates the ammoniac from this ſalt. In this experiment a large quantity of ammoniacal gas is obtained, and the reſidue is a combination of the metallic oxyd, with the muriatic acid. If biſmuth do not act on the ammoniacal muriat, in conſequence of the ſmall degree of action which the muriatic acid has on this metal, the property its oxyd poſſeſſes of decompoſing this ſalt is very remarkable, and proves that it, in ſome meaſure, reſembles ſaline ſubſtances.

Hydrogen gas alters the colour of biſmuth, and gives it a violet tinge.

Sulphur combines with this ſemi-metal by fuſion, and produces a ſort of grey mineral, of a blueiſh and brilliant appearance, which cryſtallizes in beautiful tetrahedral needles, ſimilar in colour and appearance to the fineſt ſpecimens of ſulphure of antimony[c].

The action of arſenic on biſmuth is not well known. This metal does not unite with cobalt, which remains ſeparate from it in the ſmelting.

Biſmuth is employed by the pewterers to communicate hardneſs to tin. It may be ſubſtituted inſtead of lead, in the art of cupelling the perfect metals, becauſe, like that metal, it has the property of flowing into a glaſs, which is abſorbed by the cupels. Geoffroy the younger has obſerved, and recorded many circumſtances in which this brittle metal reſembles lead. The effects of biſmuth on the animal economy can only be conjectured; but there is reaſon to think that its uſe, like that of lead, would be dangerous; and there are ſome inſtances of bad effects ariſing from the external uſe of this metal. We have already obſerved, that the oxyd of biſmuth is uſed as a pigment for the ſkin, and that ſtrong ſmelling matters alter its colour; ſuch ſmells as are fetid more particularly produce this effect. The vicinity of ſlaughter-houſes, of common ſewers, of neceſſary-houſes, and almoſt every other ſtrong ſmell, has that effect on this oxyd, and cauſes its colour to become more or leſs black. The vapour of alkaline ſulphures, or the ſmell of eggs, produce this effect very quickly. A very common experiment in natural philoſophy ſhows this property in a ſtriking manner. If characters be written with a ſolution of biſmuth on the firſt page of a book of fifty leaves, and the laſt page be impregnated with a ſmall quantity of the liquid alkaline ſulphures, a ſhort time afterwards, the hepatic vapour carried by the air, which circulates between all the leaves, arrives at the other extremity of the book, and converts the colourleſs characters marked on the firſt page into a deep brown. It is affirmed, that the ſulphurated hydrogen, or hepatic gas, paſſes through the paper; but Monge has proved, that it is the air which carries it in this manner, from one leaf to another, ſince the effect does not take place, when the leaves are glued together.

NOTES ON CHAPTER X.

BISMUTH.

[a] When cauſtic alkali is added, according to Bergman, the precipitate weighs 125 grains, but with the carbonat of alkalis, 130 grains.

[b] Oxygenated muriatic acid acts much more powerfully on biſmuth, and converts in a ſhort time to *butter of biſmuth.*

The fluoric acid diſſolves the oxyd of biſmuth. The ſolution has a ſweetiſh aſtringent taſte, and depoſits, when properly concentrated, a difficultly ſoluble fluat of biſmuth, which is decompoſable by heat.

The boracic acid has no direct action on biſmuth, but if a ſolution of borax be added to a ſolution of ſulphat of biſmuth, a white precipitate is produced, which probably is borat of biſmuth.

Phoſphoric acid has no perceptible action on biſmuth, but it produces a ſaline maſs with the oxyd that is extremely inſoluble. Phoſphat of biſmuth melts with the blow-pipe into a tranſparent glaſs that may be decompoſed by the addition of an inflammable ſubſtance. The phoſphoric acid precipitates this metal, from its ſolutions in nitric, muriatic, and ſulphuric acids.

Tartaric acid has no action on biſmuth, but it takes the oxyd from ſulphuric, nitric, or muriatic acids. Tartarit of biſmuth exiſts in the form of ſmall tranſparent cryſtalline grains.

Oxalic acid does not diſſolve the oxyd of biſmuth, but it combines with that oxyd to form a white pulverulent oxalat of biſmuth that is extremely inſoluble in water. This ſalt may be formed by adding oxalic acid to the nitric, muriatic, or ſulphuric ſolutions of biſmuth.

Acetic acid diſſolves a ſmall portion of the oxyd of biſmuth, which may be precipitated from its ſolution by the addition of phoſphoric, tartaric, or oxalic acids. *Bergman Opuſc.* Vol. III. p. 459.

The citrat and malat of biſmuth are unknown.

Benzoic acid diſſolves readily the oxyd of biſmuth. The benzoat of biſmuth is not altered by the air, but it depoſits its oxyd by dilution with water. It is decompoſed alſo by the ſulphuric and muriatic acids, and by fire.

The ſuccinic acid diſſolves the oxyd of biſmuth by boiling in water, and cryſtallizes with it into a foliated ſuccinat of biſmuth. This ſalt is decompoſed by alkalis, or its acid may be diſſipated by expoſure to the fire.

Water impregnated with carbonic acid has no action on biſmuth, but a carbonat of biſmuth may be formed, by adding an alkaline carbonat to an acid ſolution of this metal.

The gallic acid occaſions a green precipitate in a ſolution of biſmuth, but the nature of this precipitate has not been inveſtigated.

Pruſſiat of potaſh produces a yellow precipitate, which is re-diſſolved by an exceſs of the pruſſiat.

Recently prepared and moiſt oxyd of biſmuth ſeems to be diſſolved by boiling in cauſtic fixed alkalis, and by digeſtion in ammoniac.

c Expreſſed oils diſſolve the oxyd of biſmuth, and form with it a thickiſh tenaceous plaſter-like maſs. The action of ſpirit of wine, ether, and eſſential oils, is unknown.

If a ſolution of alkaline ſulphure be added to a ſolution of biſmuth in acid, a double decompoſition takes place. The biſmuth unites with the ſulphur, and is precipitated in the form of a black powder.

Biſmuth has, according to Pelletier, very little affinity for phoſphorus.

Biſmuth unites, by means of fluxes, with gold, and forms with it a pale, brittle, heavy maſs. When this maſs is expoſed in an open fire, the biſmuth is oxydated, and leaves the gold unchanged. Biſmuth precipitates gold from its ſolution in aqua regia.

Platina melts with biſmuth, and the mixture becomes fuſible in proportion to the quantity of biſmuth which it contains. The biſmuth is oxydated by expoſure to an open fire, but it is difficult to ſeparate it completely from the platina, for the mixture becomes inſoluble, in proporton as it is ſeparated. Biſmuth precipitates platina from its ſolution in aqua regia.

Biſmuth unites eaſily with ſilver, which becomes brittle, and loſes its brilliancy. By expoſing the mixture in an open fire, the biſmuth is vitrified, and the ſilver left unchanged. Biſmuth precipitates ſilver from its ſolution in nitric acid, firſt in its metallic ſtate, and at laſt in the form of an oxyd.

Biſmuth amalgamates eaſily with mercury, and is often uſed to adulterate that fluid. It is difficult to ſeparate the biſmuth again, even by diſtillation and filtration through leather. Mercury diſſolved in nitric or ſulphuric acid is precipitated in its metallic ſtate by biſmuth. If three parts of biſmuth and ſeven of oxygenated muriat of mercury be diſtilled together, a *butter of biſmuth* will be formed, and the mercury will paſs over in a fluid ſtate into the receiver. By the aſſiſtance of heat, biſmuth ſeparates the mercury alſo in a fluid ſtate from cinnabar. The reſult is a ſulphure of biſmuth.

Lead unites eaſily by fluxes with biſmuth, and by this union becomes harder, more brittle, and more fuſible. Theſe metals may be ſeparated from each other by ſolution in aqua-fortis, and dilution with water; for the water precipitates the oxyd of biſmuth, and leaves the lead in combination with the acid. Lead precipitates biſmuth from its ſolution in acids. The lead has alſo a ſtronger affinity in the dry way for ſulphur, and ſeparates it from the ſulphure of biſmuth. See *Gren's Handbuck, Wiſmuth.*

CHAPTER XI.

CONCERNING NICKEL.

Nickel was conſidered by Cronſtedt, as a peculiar ſemi-metal, when he firſt made it known in the year 1751, and 1754, in the acts of the Academy of Stockholm. This brittle metal, according to him, is of a white brilliant colour, tending to red, eſpecially at the external ſurface. It is very brittle, and in its fracture appears to be compoſed of facets, which diſtinguiſh it from cobalt. Arvidſon, who, together with Bergman, has publiſhed a theſis on the properties of nickel, which is tranſlated, and inſerted in the *Journal de Phyſique* for October 1776, obſerves, that nickel obtained by the roaſting and fuſion of its ores, as Cronſtedt directs, is far from being in a ſtate of purity, and that it contains ſulphur, arſenic, cobalt, and iron. As Bergman has ſucceeded by a great number of ingenious proceſſes to deprive it of moſt of theſe foreign matters, and to obtain nickel different from that of Cronſtedt, in many of its properties, we ſhall follow his authority, after having firſt ſpoken of its ores *.

Nickel is found united to ſulphur and arſenic. Its ores have a coppery red colour, and are almoſt always covered with a greeniſh grey efflorefcence. The Germans call it *kupfer-nickel,* or falſe copper. This mineral is very common at Freyberg in Saxony, where it is often mixed with the grey ore of cobalt; but its red colour, and its greeniſh efflorefcence, diſtinguiſh it from that ore, which is grey or black, and has a red efflorefcence. It is often cryſtallized in cubes. Wallerius diſtinguiſhes the kupfer-nickel by the name of cobalt ore, of a coppery red; he thinks it to be a compound of cobalt, iron and arſenic. Linnæus conſidered it as copper mineralized by arſenic. Romé de Liſle has arranged it, with Wallerius, among the ores of cobalt, and, like him, thinks that it is a compound. Sage having treated this ore with muriat of ammoniac, obtained iron, copper, and cobalt; he thinks that it is compoſed of theſe three metallic matters, together with arſenic. It likewiſe contains a ſmall proportion of gold, according to this chemiſt. It is proper to obſerve, theſe reſults do not agree with thoſe of Bergman; he is ſaid to have operated upon the kupfer-nickel of Biber in Heſſe, and of Allemont in Dauphiny.

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* This Eſſay is printed in the ſecond volume of the Engliſh tranſlation of Bergman's Eſſays. T.

Cronſtedt aſſures us, that the metallic matter called *ſpeiſs* by the Germans, which is collected in the crucibles uſed in the melting of ſmelt, affords nickel. Monnet thinks that the ſpeiſs of the manufacture of Gengenback, 14 leagues from Straſburg, is true nickel; and as the ore of cobalt made uſe of in that place to make ſmalt is very pure, he concludes that nickel is neceſſarily a product of cobalt itſelf, as we ſhall preſently ſee. But Baumé has obtained nickel from almoſt all the ores of cobalt by means of an alkaline ſulphure; it therefore ſeems that the ore of cobalt, which is wrought at Gengenback, contains nickel not diſtinguiſhable by the eye, on account of the intimate union of theſe two metallic matters.

To obtain nickel from the ore, it is ſlowly roaſted, in order to drive off a portion of the ſulphur and arſenic it contains. It is by this means converted into a greeniſh oxyd. The greener it is, the greater the quantity of nickel it contains, according to Bergman and Arvidſon. It is afterwards melted with three parts of black flux and muriat of ſoda, and a metal is by that means obtained, ſuch as Cronſtedt ſpeaks of, but which is far from being pure nickel. Its ſcoriæ are brown or blue. Many chemiſts, ſince the experiments of Arvidſon, ſtill continue to think that this metallic ſubſtance is a natural alloy of iron, cobalt, and arſenic; as to copper, there is no chemiſt but Sage, who affirms that he has obtained it from kupfer-nickle, Monnet thinks that nickel is cobalt, deprived of iron and arſenic. In proportion as we ſhall proceed in the examination of the properties of this metal, we ſhall perceive the cauſes of theſe different opinions having been adopted. We think with Bergman, that the extreme difficulty of obtaining nickel in a ſtate of purity, is the circumſtance which has deceived the generality of chemiſts; and this truth is fully proved in the diſſertation of Arvidſon, already quoted. As it is certain that this metallic ſubſtance has very peculiar properties, however pure it may be made; and that no means of ſeparating it by analyſis into different metallic ſubſtances, nor of recompoſing it by any mixture, have been yet diſcovered; it ought to be regarded as a peculiar metal, till further experiments ſhall convince us to the contrary.

The metal which affords, by ſimple fuſion, kupfer-nickel, is of a reddiſh white, very brittle, and of a plated texture. It contains much arſenic, cobalt, and iron. Mr. Arvidſon ſubjected it to ſix calcinations, each for the ſpace of between ſix and fourteen hours, and reduced the metal after each calcination. During the calcination, he obſerved that vapours of arſenic, and white vapours which have not the ſmell of this ſemimetal, were driven off: the powder of charcoal added in theſe operations, facilitated the volatilization of the arſenic. The nickel, whoſe weight was greatly diminiſhed by theſe ſix calcinations, ſtill had an arſenical ſmell, and continued to be attracted by the magnet. It was then fuſed ſix times with lime and borax, and calcined a ſeventh time, with the addition of charcoal, till it no longer ſent forth arſenical fumes: this oxyd was ferruginous, and ſtriped with green. When reduced, it afforded martial ſcoria, and a button ſtill obedient to the magnet. Theſe experiments have always ſucceeded in the ſame manner with many ſpecimens of nickel from different countries. Treatment with ſulphur, and ſulphure of potaſh, detonation with nitre, ſolution in the nitric acid, and in ammoniac, made by Arvidſon, never deprived nickel of all its iron. From theſe experiments he concluded, that it is impoſſible to purify this metal accurately; that the ſulphur is not ſeparated but by repeated calcinations; that the arſenic adheres ſtill more ſtrongly; that it may be drawn off by the aſſiſtance of powder of charcoal and of nitre; that cobalt is ſtill more intimately combined with this metal, ſince the nitre ſhows its preſence though no other indications were before perceived; and that it is impoſſible to deprive it of all the iron it contains, becauſe when the nickel has been treated in all theſe various manners, it is ſometimes more ſtrongly attracted by the magnet than before. Arvidſon thinks, from theſe circumſtances, that this ſubſtance is nothing elſe but iron in a peculiar ſtate, and he has drawn up a comparative view of many of the properties of cobalt, of loadſtone, and of nickel; from which he conſiders theſe three metallic matters as iron differently modified. But as the principal property of nickel, which has led Arvidſon to this concluſion, is its magnetiſm; may we not conclude that theſe two metallic ſubſtances, ſo different in all their other properties, are not to be confounded together on this account? for it has not been proved that magnetiſm is peculiar to iron, or that it may not exiſt in many other metallic ſubſtances. I think therefore, that notwithſtanding the property of being attracted by the magnet, which nickel poſſeſſes, it ought to be conſidered, when purified by the proceſſes of Arvidſon, as a peculiar metal; ſince it cannot be extracted either from other metallic ſubſtances, nor can be perfectly imitated by any mixture; and laſtly, becauſe it poſſeſſes properties common to no other metal, as we ſhall proceed to ſhow. Kirwan has entirely adopted this opinion in his Mineralogy.

Its texture is not plated, as Cronſtedt aſſerted, but granulated, as its fracture ſhows. It is nine times heavier than water. It is not brittle, but, on the contrary, ſufficiently ductile to make it a queſtion with Bergman, whether he ſhould rank it among the metals or ſemi-metals. It is nearly as difficult to melt as forged iron, is extremely fixed in the fire, and becomes calcined when heated with acceſs of air, affording an oxyd of a green colour, which is deeper in proportion to its purity: it is not known whether this oxyd is fuſible into glaſs. The fluxes and combuſtible matters commonly uſed in reducing the metals, produce their effect with this. The action of air and water on nickel are not known: its oxyd, when melted with matters proper to form glaſs, gives them a hyacinthine colour, more or leſs red. The action of lime, magneſia, and the three pure alkalis, on nickel, are ſtill unknown.

Sage affirms, that when four parts of concentrated ſulphuric acid are diſtilled from one part of the regulus of kupfer-nickel, in powder, the ſulphureous acid paſſes over: the reſidue is greyiſh, and being diſſolved in diſtilled water, produces the moſt beautiful green colour. The cryſtals obtained from this ſolution are foliated, and of the colour of an emerald. According to Arvidſon, the ſulphuric acid forms a green ſalt, in decahedral cryſtals, with the oxyd of nickel. Theſe conſiſt of two quadrangular pyramids, united together and truncated near their baſe [a].

This oxyd is eaſily ſoluble in the nitric acid, and cryſtallizes in rhombic cubes [b]. According to Sage, all the other ſolutions of nickel, or its oxyd, either in the muriatic acid, or in vegetable acids, are more or leſs green [c]. Fixed alkalis precipitate it of a greeniſh white colour, and re-diſſolve it, at which period the liquid becomes yellowiſh. Ammoniac poured into an acid ſolution of nickel produces a beautiful blue colour; this ſalt preſents the ſame phenomena when mixed with the precipitates of this metal, by fixed alkalis. As the ſolutions of copper exhibit the ſame colour with ammoniac, which is eſteemed a very proper teſt of the preſence of copper, it has been thought that nickel contains this metal. Cronſtedt, however, tried in vain all the known methods of extracting copper from the ſolution of nickel, tinged blue by ammoniac. This ſalt, beſides, does not immediately diſſolve nickel, as it does copper. It is therefore proved, as Bergman thinks, that the property of turning green belongs to nickel itſelf, and is not owing to the preſence of copper. This chemiſt did not obſerve any certain ſigns of the ſolution of nickel by the carbonic acid, in an experiment where he kept this metal for eight days in water impregnated with that acid [d].

Nickel detonates with nitre; this detonation afforded Arvidſon a method of diſcovering the preſence of cobalt, which no other proof had rendered ſenſible. The nickel is more or leſs oxydated in proportion to the quantity of nitre employed. This neutral ſalt has likewiſe the property of augmenting the intenſity of the hyacinthine colour, communicated by oxyd of nickel to glaſſes, and of cauſing it to re-appear after it has been diſſipated by heat, as frequently happens with this oxyd in glaſs, and is common to it with the ſemi-metal we ſhall next proceed to examine.

The oxyd of nickel fuſed with borax likewiſe gives it an hyacinthine colour.

It partly decompoſes muriat of ammoniac. The martial flowers obtained by Sage, in this experiment, aroſe from his not having employed a regulus as pure as that of Arvidſon; for this laſt chemiſt aſſures us, that ammoniacal muriat ſublimed with this metal was white, and gave no indication of the preſence of iron, by the teſt of nut galls: a ſmall quantity of ammoniac and muriatic acid paſs into the receiver; the reſidue, when reduced, affords nickel partly deprived of its magnetiſm.

The action of hydrogen gas on nickel is not yet known.

This metal combines readily by fuſion with ſulphur, and then forms a kind of hard mineral, of a yellow colour, with ſmall brilliant plates. When ſtrongly heated in contact with air, it deflagrates, and emits very luminous ſparks, ſimilar to thoſe afforded by iron when forged. Cronſtedt, who firſt made this experiment, did not purſue it; he obſerved only, that the phenomenon does not take place, if the contact of air be prevented, by covering the metal with glaſs in fuſion; which ſhows that this effect is owing to the rapid combuſtion of the nickel produced by the ſulphur. The ſame chemiſt acquaints us, that this metal is ſoluble in alkaline ſulphures, and forms a compound reſembling the yellow ores of copper. The ſulphur cannot be ſeparated from nickel but by repeated fuſions and calcinations[e].

Nickel combines with arſenic, to which it has a ſtrong attraction. Monnet, who at firſt, after Cronſtedt, conſidered nickel as a peculiar metal, having obſerved that it forms a blue glaſs when united to arſenic, ſimilar to that which cobalt affords, adopted the opinion that nickel is nothing elſe but cobalt deprived of arſenic and iron. Monnet therefore conſiders cobalt, as well as nickel, as a metallic mixture. Bergman thinks, that if a blue glaſs be obtained, by the addition of arſenic to nickel, no other conſequence ought to be deduced, than that it is cauſed by the cobalt which it is known to contain, and whoſe properties are hidden by the latter till it is oxydated and ſeparated from the nickel by means of arſenic; at which time its properties, more eſpecially that of flowing into a glaſs of a blue tinge, ſhow themſelves. We have already obſerved, that nickel cannot be entirely ſeparated from arſenic, but by repeated calcinations, with the addition of charcoal in powder. Nickel unites ſtill more intimately to cobalt than to arſenic, ſo that they cannot be ſeparated without the greateſt difficulty.

Cobalt may exiſt in this combination without ſhowing any indications of its principal properties. Nitre, borax, and arſenic, are the only ſubſtances by which its preſence can be exhibited in fuſion.

Cronſtedt affirms, that nickel forms with biſmuth a brittle and ſcaly regulus; the ſolution in the nitric acid ſeparates theſe two metallic ſubſtances imperfectly, by virtue of the property which nitrat of biſmuth poſſeſſes of being decompoſed by water. No uſe has yet been made of nickel.

NOTES ON CHAPTER XI.

NICKEL.

a Sulphat of nickel is ſoluble by heat in its own water of cryſtallization. The ſulphuric acid may be diſſipated by expoſure to a ſtrong fire. The fixed alkalis and earths precipitate nickel from this ſalt of a pale green colour. Ammoniac occaſions a blue precipitate, which may be re-diſſolved by an exceſs of ammoniac.

b The cryſtals of nitrat of nickel deliqueſce in a moiſt, and effloreſce in a warm dry air. Nickel precipitated from nitric acid by cauſtic alkalis has acquired an additional weight of 28 per cent.; that by carbonat of alkalis 35 per cent. The carbonic acid is expelled from this combination by a very moderate heat.

c Muriatic acid diſſolves nickel and its oxyd in a very ſlow manner, even when aſſiſted by heat. By evaporation this combination ſhoots into long rhomboidal cryſtals, which deliqueſce in a moiſt air. They are ſaid not only to effloreſce, but even to part with their acid, if they be kept long in a dry and warm atmoſphere. The order of the affinities of the ſulphuric, muriatic, and nitric acids, is not known.

d Fluoric acid diſſolves oxyd of nickel with difficulty, and forms with it green coloured cryſtals.

Boracic acid ſeems to have little or no direct action on nickel; but if an acid ſolution of this metal be mixed with a ſolution of borax, a borat of nickel will be formed. This ſalt is very inſoluble in water. In the fire it melts into a hyacinthine coloured glaſs.

Phoſphoric acid exerts very little action on nickel, and forms with it, according to Bergman, a ſcarcely perceptible greeniſh ſolution. Theſe ſubſtances unite eaſily by fuſion.

The tartarit, malat, and citrat of nickel, are little known.

Oxalic acid combines with the oxyd of nickel, and forms with it a ſalt which is very inſoluble in water. This acid diſengages nickel from all its other acid combinations.

Acetic acid diſſolves the oxyd of nickel, and forms with it green coloured rhomboidal cryſtals.

Pruſſiat of alkali precipitates nickel of a pale green colour from its acid combination.

With the gallic acid this precipitate is of a white colour.

Nickel unites readily with and takes up a conſiderable portion of phoſphorus.

Nickel unites readily with gold, and renders that metal white and brittle. It may be ſeparated from the gold by oxydation. Nickel melts alſo with platina.

Silver melts eaſily with nickel, without loſing much of its colour or ductility. If this mixture be detonated with nitrat of potaſh, the nickel will be oxydated, and the ſilver remain unchanged. Nickel precipitates ſilver from its ſolution in nitric acid.

Nickel does not amalgamate with mercury. In the heat it diſengages the mercury from cinnabar, by uniting with the ſulphur.

The combination with lead unknown, as well as the relative affinities of theſe metals for acids.

Nickel unites with biſmuth into a brittle laminated maſs. Their mutual affinities for acids are likewiſe undetermined.

Gren's Handbuck, Nickel metal. Richter Ueber die Neu. Gegen. St. IX. ſ. 64.

CHAPTER XII.

CONCERNING MANGANESE.

MANGANESE, a grey dark coloured mineral, which ſoils the fingers, and is employed in glaſs-houſes in different proportions, either to colour, or to take away colour from glaſs, has been long known by the name of *black magneſia*, or *manganeſe*. Workmen have called it the *ſoap of glaſs*, from its property of rendering it colourleſs. Many naturaliſts, judging by its colour, and the ferruginous earth with which its ſurface is often covered, have taken it for a meagre ore of iron. Pott and Cronſtedt, after an exact analyſis, did not conſider it as a ferruginous matter. The latter affirmed that it contains a ſmall proportion of tin. Sage reckons it among the ores of zink, and thinks that it is formed by the combination of that ſemi-metal and cobalt with the muriatic acid; he adds, from his own trials, that it ſometimes contains iron or lead.

The weight of manganeſe, its property of tinging glaſs, and of affording a whitiſh precipitate when the alkaline pruſſiat is poured into its ſolutions, cauſed Bergman to ſuſpect, as he acquaints us in the laſt paragraph of his diſſertation on the Elective Affinities, that this mineral contains a peculiar metallic ſubſtance. His ſuſpicion has been fully confirmed by one of his diſciples, Mr. Gahn, doctor in medicine at Stockholm, to whom, together with Scheele, we are indebted for the diſcovery of the phoſphoric acid in bones. This phyſician is the firſt who obtained a regulus of manganeſe, probably by treating it with reducing flux. The degree of fire neceſſary for this operation, is, doubtleſs, very great; for I have been a witneſs to the attempts of Brongniart, an experienced chemiſt, who tried in vain to reduce it in a furnace which was capable of producing an exceſſive degree of heat. I have been aſſured, that the reduction has been ſucceſsfully performed at Paris by employing the flux of Morveau, with which this chemiſt obtained iron in a very well formed button: but I think that La Peyrouſe is much in the right in his opinion, that fluxes are pernicious in this operation. I have attempted the reduction in an excellent melting furnace, conſtructed in the laboratory of the Veterinarian ſchool at Alfort. I have not yet obtained a perfect button, but I have obtained a conſiderable quantity of metallic globules, two or three lines in diameter. On ſeveral occaſions, when I have employed fixed alkalis and borax, no metal was reduced. In my trials, each ſmall metallic globule of manganeſe was incruſted with glaſs, or a vitreous frit of a deep colour. Manganeſe ought to be conſidered as a peculiar metal, becauſe its analyſis has not yet been made, and it is found to poſſeſs properties common to no other metallic ſubſtance.

The properties of this metal have been greatly elucidated by the labours of Bergman, Scheele, Gahn, Rinman, Engeſtroem, Iſlemann, and Peyrouſe. It is from the labours of theſe chemiſts, as well as from my own particular experiments, that I ſhall borrow the following account of this ſubſtance; firſt obſerving, that the difficulty of reducing the ores of this metal, is the cauſe why we are much better acquainted with the properties of its oxyd than with thoſe of the metallic ſubſtance itſelf. Scheele, one of the firſt chemiſts of the preſent age, does not appear to have ſucceeded in reducing it, ſince he no where ſpeaks of the properties it poſſeſſes in the metallic ſtate.

The ores of manganeſe are known by their grey, brown, or black colour, more or leſs brilliant, and likewiſe by their external appearance: they may be diſtinguiſhed into a conſiderable number of varieties.

Variety

1. Ore of manganeſe cryſtallized in tetrahedral rhomboidal priſms, ſtriated in the direction of their length, and ſeparated from each other.
2. Cryſtallized ore of manganeſe, whoſe priſms are diſpoſed in bundles, or aggregates.
3. Cryſtallized ore of manganeſe, in ſmall needles, diſpoſed in the form of ſtars.
4. Effloreſcent ore of manganeſe, black and friable; it ſoils the fingers like ſoot.
5. Velvet ore of manganeſe; theſe are very ſmall needles,

which falling into efflorefcence, have a beautiful dead colour, refembling velvet.

6. Compact and amorphous ore of manganeſe, of a black grey, often with cavities, and very heavy; it ſoils the fingers, and is ſometimes found in brilliant needles. The Perigord ſtone belongs to this variety.
7. Spathoſe manganeſe, found in the iron mines of Klapperud, at Freſco in Dalecarlia, and deſcribed by Mr. Rimman.
8. Native manganeſe, in metallic globules, found at Sem, in the county of Foix, by la Peyrouſe, and deſcribed by him, together with many varieties of the ores of manganeſe, found at the ſame place, in the *Journal de Phyſique* for January 1780.

Scheele has diſcovered the oxyd of manganeſe in the aſhes of vegetables, and attributes the green and blue colour, which fixed alkali often takes in calcination to its preſence. The green colour of potaſh, treated with lime, and the roſe colour which I have often obſerved in its combination with acids, ariſes, no doubt, from this metallic oxyd. A ſmall portion of this ſubſtance is found in all charcoals.

Manganeſe, extracted from its ore, is of a brilliant white; when broken, its texture appears granulated like that of cobalt. It is hard, and breaks, after being in a ſmall degree flattened by the hammer [a]. Its infuſibility is greater than that of iron, which at firſt cauſed Bergman to conjecture, that it has ſome affinity with platina; if it be heated with contact of air, it is converted into an oxyd, at firſt whitiſh, which becomes more and more black, in proportion as the oxydation proceeds. I have obſerved that the ſmall globules of manganeſe, obtained by the proceſs I have before ſpoken of, very ſoon change by the contact of air; they are tarniſhed, and become of a lilac and violet colour. Soon afterwards they fall into a black powder, and then reſemble the native oxyd of manganeſe.

This rapid oxydation of the regulus of manganeſe by the contact of air, is a fact which I have always conſidered as very ſingular. The metallic globules, which are hard, brilliant, and very refractory, remain entire for a long time in a well cloſed bottle, provided their ſurface be entire, and covered with that ſmall ſtratum of oxyd which is formed during the fuſion of this ſemi-metal: but if one of theſe globules be broken into three or four fragments, we find, by fixing the eye for ſome minutes upon their fracture, expoſed to the air, that their colour is quickly altered; that, inſtead of the white colour it had before, it becomes very ſpeedily of a roſe, purple, or violet colour, and at laſt almoſt brown. If the fragments be left in a bottle which contains, at the ſame time, a certain quantity of air, and they be ſhaken from time to time, it is found, at the end of ſome months, that they are reduced into a powder which is almoſt black. This is a ſort of pulverization, or metallic efflorеſcence, analogous to that of ſaline ſubſtances or pyrites. It proves the ſtrong attraction which exiſts between manganeſe and the atmoſpherical oxygen, and the rapidity with which theſe ſubſtances tend to unite.

The action of manganeſe on earths, and the ſalino-terreſtrial ſubſtances, has not yet been examined; the oxyd of this metal gives a violet or brown colour to glaſs, ſuſceptible of a great number of modifications, but eaſily deſtroyed by the action of combuſtible ſubſtances. Nitre revivifies, or cauſes the ſpeedy re-appearance of this brown or violet colour, by reſtoring the oxygen to the manganeſe. This is the reaſon why the matraſſes and retorts of white glaſs, which we uſe in our laboratories to obtain vital air from nitre, always acquire a brown or violet colour. Scheele has made a great number of ingenious experiments on this head.

The manner in which fixed alkalis act on manganeſe is not well known; but the oxyd of this metal combines with the ammoniac, and is revived. Bergman obſerves, that in this combination a peculiar gas is diſengaged, which he regards as one of the principles of the ammoniac, but of which he does not ſpeak fully. It appears from the diſcovery of Berthollet to be azotic gas, and that the hydrogen of the ammoniac combines with the oxygen, and takes it from the manganeſe, which is thus reduced, and becomes white.

Scheele has given the name of *cameleon mineral* to a combination of potaſh and oxyd of manganeſe, which aſſumes a beautiful green colour in hot water, and is red in cold water.

The oxygen and caloric appear to be the principal cauſes of the phenomena preſented by this combination. Perhaps the azote, which I conſider as the alkalifying or *alkaligène* principle, may diſengage itſelf from the potaſh in this operation, and may partly occaſion theſe ſingular modifications of colour.

The ſulphuric acid diſſolves mangaueſe and its oxyds; this laſt ſolution is coloured, but becomes clear by the addition of any combuſtible matter, ſuch as ſugar or honey. It affords a tranſparent ſulphat of manganeſe in priſmatic cryſtals with parallel ſides. This ſulphat is decompoſed by fire, and affords vital air. The alkalis ſeparate an oxyd of manganeſe, which becomes brown by expoſure to the air [b].

The nitric acid likewiſe diſſolves it, emitting at the ſame time red vapours. Its oxyd is not attacked by this acid, unleſs it be fuming, or ſome combuſtible body, ſuch as honey or ſugar be added. Alkalis precipitate from its ſolutions a white oxyd, ſoluble in acids, which, when heated, becomes black, and is oxydated ſtill more. Bergman thinks that this metal has a greater affinity with ſalts than moſt metallic ſubſtances; he places it in his table, near the top of that column which contains the elective attractions of acids.

The muriatic acid likewiſe diſſolves manganeſe, which gives it a deep brown colour; when this ſolution is heated, the colour diſappears; water occaſions a precipitate, and alkalis decompoſe it.

In the hiſtory of this acid we have ſeen, that when diſtilled from the native oxyd of manganeſe, it becomes white, and approaches to the metallic ſtate, by giving out a part of its oxygen to the muriatic acid, which is diſengaged in the form of oxygenated muriatic acid gas. The muriatic acid ſeems to have a ſtronger affinity with manganeſe than the ſulphuric; for the ſolution of this metal by the latter, being poured into muriatic acid, forms a precipitate, which Bergman found to be muriat of manganeſe, by the property it has of diſſolving in ſpirits of wine; a property which the ſulphat of the ſame metal does not poſſeſs.

The fluoric acid diſſolves the oxyd of manganeſe very ſparingly. Theſe two ſubſtances are more eaſily united, according to Scheele, by decompoſing the ſulphat, the nitrat, or the muriat of manganeſe, by ammoniacal fluat.

The carbonic acid diſſolves a ſmall quantity of manganeſe, by digeſtion in the cold. Potaſh, and ſimple expoſure to air, precipitate the metallic oxyd from this acid [c].

Scheele has examined the action of nitre, borax, and muriat of ammoniac, on the oxyd of manganeſe. This oxyd diſengages the acid of nitre by the aſſiſtance of heat; with potaſh it forms a deep green maſs, ſoluble in water, to which it communicates the ſame colour. The greenneſs ariſes from the iron contained in the manganeſe; and in proportion as this falls down the ſolution becomes blue. Water and acids precipitate this alkaline ſolution. It is the cameleon mineral of Scheele, which we have already ſpoken of.

Nitrat of potaſh, heated in veſſels made of glaſs, containing manganeſe, communicates a violet colour to the glaſs, which is ſo much the deeper, as the oxydation of this metal by the nitric acid is more complete.

Borax, melted with oxyd of manganeſe, aſſumes a brown or violet colour.

Muriat of ammoniac, diſtilled from this metallic oxyd, affords ammoniac in part decompoſed. Scheele, who made the ſame obſervation, informs us, that an elaſtic fluid, which he eſteems to be one of the principles of ammoniac, is at the ſame time diſengaged. But he has not pointed out the nature of this fluid, which Berthollet has diſcovered in another way. This laſt chemiſt decompoſes the ammoniac by means of metallic oxyds; in which proceſs water is formed by the union of hydrogen, one of the principles of this ſalt, with the oxygen of the oxyds, while the azote, or the other principle of the ammoniac, is diſengaged in the aeriform ſtate. Nitric acid is likewiſe formed during this proceſs.

The action of hydrogen gas, and of ſulphur, on manganeſe, or on its natural oxyd, is not known; arſenic, in the ſtate of a white oxyd, appears capable of taking from this laſt a portion of its oxygen, ſince it deprives glaſſes of colour, after they have become brown by means of manganeſe [d].

To theſe properties Bergman adds, that manganeſe cannot be abſolutely purified from the iron it already contains, and therefore this metal, like nickel, has not yet been obtained in a ſtate of perfect purity. Scheele, in the accurate analyſis which he has made of the natural oxyd of mangaueſe, found it to contain iron, lime, barytes, and a ſmall proportion of ſilex[e].

The black oxyd of manganeſe, called *black magneſia*, is uſed in glaſs-houſes, to take away the yellow, green, or blue tinge from glaſs, intended to be of a clear white; a large proportion gives glaſs a violet colour. It is probable that this phenomenon is a conſequence of the action of the oxygen ſeparated from manganeſe by heat, on the colouring ſubſtances. The oxyd of manganeſe is at preſent uſed in chemiſtry, to prepare the oxygenated muriatic acid, and for a great number of other experiments.

This native oxyd affords, by mere heat in the pneumato-chemical apparatus, very pure vital air, or oxygenous gas. It is this vital air alone which can be uſed to advantage by patients whoſe diſorders require the adminiſtration of this fluid. It is to be remarked, that in diſtilling the native oxyd of manganeſe, in order to obtain vital air in a very pure ſtate, the retort muſt be completely filled with this ſubſtance, ſo as to allow no atmoſpherical air to remain in the retort. It is in this way that the vital air intended for the uſe of the ſick, or for the compoſition of water, ought to be prepared. Without this precaution, a conſiderable quantity of nitric acid will be formed, or a mephitic reſidue produced, which ſtops the combuſtion of the hydrogen gas, and renders it neceſſary to empty the receiver.

The affinity of manganeſe for the principle of combuſtion ſerves likewiſe to guide modern chemiſts in a great number of caſes, and may lead to diſcoveries concerning the nature of many ſubſtances at preſent unknown.

NOTES ON CHAPTER XII.

MANGANESE.

a THE ſpecific gravity of this metal has been eſtimated at 6850 by Bergman, and at 7000 by Hielm.

b Mr. Kirwan remarks, that the diluted acid, in combining with mangaueſe, leaves undiſſolved a black ſpongy maſs, which he ſeems inclined to conſider as carbon, this metal had abſorbed during its reduction.

If ſulphuric acid be diſtilled over manganeſe, oxygen gas is diſengaged from this ſubſtance in conſiderable quantity. See *Ann. de Chem.* Tom VII. p. 287.

c Precipitated by an alkaline carbonat, the manganeſe gains in weight an addition of 80 per cent. by cauſtic alkalis, an addition of 68.

The combination of manganeſe with boracic acid has not been aſcertained.

Phoſphoric acid combines with manganeſe to form the phoſphat. This ſalt is moſt eaſily prepared, by adding a ſolution of manganeſe in ſulphuric, nitric, or muriatic acids, to a ſolution of phoſphat of ammoniac.

Tartaric acid diſſolves black oxyd of manganeſe in the cold, without efferveſcence. If this ſolution, which is of a reddiſh brown colour, be expoſed to heat, the colour diſappears, and acetic acid is diſengaged. The remaining ſolution has not been properly examined. It probably contains acetat of manganeſe. The tartarit of manganeſe is formed by diſſolving the white oxyd of manganeſe in tartaric acid. This is very inſoluble in water.

Oxalic acid combines ſtrongly with manganeſe and its oxyd. The ſalt which it forms becomes ſoluble in water by an exceſs of acid. It is decompoſed in the fire. Oxalic acid takes manganeſe from ſulphuric, nitric, and muriatic acids.

The black oxyd of manganeſe is diſſolved with difficulty, but the white very eaſily by digeſtion in acetic acid. The ſolution is colourleſs, and affords by evaporation ſmall cryſtals of a very deliqueſcent ſalt.

The ſuccinat, malat, and citrat of manganeſe, are unknown.

Pruſſiat of alkali precipitates manganeſe from its ſolution in acids, and forms with it a pruſſiat of that metal.

d Manganeſe does not appear to unite with ſulphur. If eight parts of oxyd of manganeſe be diſtilled with three of ſulphur, ſulphureous acid gas will be diſengaged, and an imperfect oxyd of manganeſe left behind in the retort. If this mixture be calcined in an open veſſel, ſulphat of manganeſe will be produced.

Phoſphorus unites very well with manganeſe. A phoſphure of this metal may be formed, by melting in a covered crucible equal parts of vitreous phoſphoric acid and manganeſe with one-fifteenth of charcoal duſt. This phoſphure has a white colour and metallic luſtre, is unchangeable in the air, brittle, granular in its fracture, and more fuſible than manganeſe.

On account of the difficult fuſibility, and eaſy oxydation of manganeſe, it is neceſſary, in order to combine it with other metals, to uſe a very ſtrong heat, and to keep the metallic mixture carefully excluded from the external air.

Combined in a large proportion with gold and ſilver, manganeſe renders theſe metals very brittle. It precipitates ſilver from acids in a ſtate nearly approaching to the metallic.

Mercury and manganeſe do not enter into combination. Manganeſe precipitates mercury from its ſolution in acids; oxyd of manganeſe has no action on the oxygenated muriat of mercury; but, diſtilled in the proportion of two to one with ordinary muriat, it converts the mercurial muriat into the oxygenated. During its diſtillation with cinnabar, ſulphuric acid gas, and fluid mercury, are diſengaged.

Lead, according to Gmelin, unites with great difficulty to manganeſe. The properties of the lead, by this admixture, are but little changed.

Copper unites, by repeated meltings, with manganeſe, and forms with it a white malleable metallic maſs. Manganeſe does not precipitate it from its ſolution in acids.

Arſenic forms a metallic mixture by melting it in cloſe veſſels with manganeſe. In diſtillation together, the white oxyd of arſenic paſſes over unchanged. *Gren's Handbuck Magneſiumoder Braunſtein metall.*

[c] To obtain manganeſe free from iron, Richter recommends the following proceſs. A ſaturated ſolution of ſulphat of manganeſe is to be mixed with a ſolution of tartarit of potaſh, and the mixture placed on a ſand bath. In the courſe of a few minutes, a white precipitate is formed, which increaſes in proportion as the fluid is evaporated. When the evaporation has been carried ſo far on, that the ſulphat of potaſh is diſpoſed to cryſtallize, the clear liquor is to be decanted off, and the precipitate well edulcorated with a ſmall quantity of water. The water uſed for edulcoration, together with a freſh quantity of the tartarit of potaſh, is to be added to the liquor, in order that any manganeſe which they contain may be precipitated. The precipitate, which is a pure tartarit of manganeſe, may be decompoſed by a ſtrong fire, and ſubjected to the uſual proceſs for obtaining this ſubſtance in its metallic ſtate. See *Richter, neu. Gegenſt. St.* I. ſ. 32.

CHAPTER XIII.

OF ANTIMONY.

Antimony, *ſtibium*, is a brittle heavy metal, of a brilliant white, reſembling that of tin or ſilver; it is compoſed of plates applied upon each other, and preſents upon its ſurface a ſort of cryſtallization, in the form of a ſtar, or leaves of fern. It is likewiſe capable of cryſtallizing in trihedral pyramids, formed as it were of a kind of hoppers implanted into each by their angles; theſe hoppers appear to be themſelves the reſult of the aggregation of quadrangular or octahedral pyramids. Immerſed in water, it loſes 1-7th of its weight. It is eaſily reduced into powder, and has a very ſenſible taſte or action on the ſtomach, being powerfully emetic and purgative.

Antimony is ſeldom found native. It has been diſcovered by Mr. Anthony Shwab, at Salberg in Sweden. Schrieber, director of the mines at Almont, in Dauphiny, found it in thoſe mines. This native antimony is in large plates, and poſſeſſes all the properties of that procured by art, excepting that it contains one or two hundredth parts of arſenic.

Mongez, the younger, has diſcovered a native oxyd of antimony, in fine white needles, mixed with antimony, or grouped ſo as to reſemble zeolite. He found this oxyd on native antimony from Chalanges in Dauphiny.

This metal is moſt commonly combined with ſulphur, and then forms what is improperly called antimony, and ought to be denominated ore or ſulphure of antimony. This mineral is of a blackiſh grey, in brittle plates or needles, of various magnitudes, joined together in different forms. It is ſometimes mixed with other metals, particularly lead and iron; and is very common in Hungary, and in the provinces of Bourbon, Auvergne, and Poitou. Naturaliſts have multiplied the varieties of antimony, accordingly as the fibres of the mineral are parallel, divergent, irregular, chatoyant, &c. When antimony is mixed with a portion of arſenic, or when it is altered by alkaline vapours, or combuſtible ſubſtances, its needles are of a deep red, nearly reſembling the fine flowers of cobalt, but rather more opake. The following are admitted as varieties of this ore.

Variety

1. Sulphure of antimony cryſtallized in ſeparate hexahedral priſms, terminated by tetrahedral obtuſe iſolated pyramids.
2. Striated ſulphure of antimony, in the form of large irregularly formed needles, united in irregular bundles.
3. Sulphure of antimony, with divergent needles iſſuing from one common centre.
4. Lamellated ſulphure of antimony, the laminæ of various ſizes, and reſembling the lead ore called galena. This variety is ſometimes brilliant, and is then called *ſpecular antimony*.
5. Red ſulphure of antimony. It has the appearance of a granulated efflorescence on the ſurface of the needles of antimony; it is ſometimes cryſtallized in red needles, or priſms, of various degrees of brilliancy. Some naturaliſts call this *kermes*, or *golden ſulphur of antimony*.

The ſulphures of antimony are not commonly treated with the intention of ſeparating the pure metal. In general, nothing more is done than the application of a ſufficient heat to ſeparate the metal from its gangue, and other metallic matters with which it may be mixed. For this purpoſe two earthen pots are taken, one of which is pierced at the bottom in many places; into this the ore is put; another pot, placed below the firſt, for the purpoſe of receiving the ſulphure of antimony in proportion as it melts, being ſunk in the earth. A fire is then made about the ſuperior pot, ſo as to produce gentle heat at the beginning, becauſe the antimony is very fuſible; but towards the end the heat is raiſed, that the whole of the antimony contained in the mineral may be melted out. At this period of the proceſs a portion of other metals falls down, more eſpecially iron, and forms a bed of ſcoriæ on the ſurface of the ſulphure of antimony. Though the antimony of Hungary is reckoned the pureſt, it is certain that all ſulphure of antimony which has been melted, if it be in the form of perfect needles, and without mixture of ſcoriæ, is equally proper for all the uſes in which this mineral is employed. It muſt only be obſerved, that ſulphure of antimony often differs in the relative quantity of ſulphur and antimony which it contains, and that it is of great conſequence to make an aſſay of ſuch ſpecimens as are intended to be uſed in the preparation of ſuch antimonial medicines as are intended in all caſes to have the ſame force or efficacy.

The proceſs employed to ſeparate ſulphure of antimony from its gangue, ſhows that it is very fuſible. If the fire be raiſed when it is melted in open veſſels, it parts with the ſulphur, which is diſſipated in yellow flowers. The metallic part is likewiſe very eaſily oxydated, and diſſipated in white flowers. But if a mild heat, not ſufficient to melt the ſulphure of antimony, be employed, the ſulphur of the mineral is diſſipated ſlowly, and by degrees; the metal uniting gradually to the oxygen of the atmoſphere, and forming the grey oxyd of antimony. This operation cannot be well performed, unleſs the ſulphure of antimony be in a ſtate of minute diviſion, ſo as to preſent a large ſurface to the air. It is therefore reduced to powder, and expoſed to a low heat in a ſhallow veſſel of glazed earth. The proceſs muſt likewiſe be conducted with caution at the beginning, becauſe of the fuſibility of the antimony; but in proportion as it goes on, and the ſulphur is diſſipated, the antimony becomes more refractory, and the fire may be raiſed to ſuch a degree as to make the capſule, in which the mineral is contained, red hot. It is a proof that the operation is well conducted, when no other ſmell but that of ſulphur is perceived during the roaſting, and the matter does not gather into clots. But when, on the contrary, the ſulphure of antimony gathers together in lumps, and the ſulphur is decompoſed during its volatization, which may be perceived by the ſuffocating ſmell of the ſulphureous acid, the heat is too great, and muſt be diminiſhed.

Though ſulphur ſeems to adhere very weakly to antimony, in the ore we are treating of, it is not poſſible to drive it off entirely by roaſting; and the grey oxyd of antimony always retains a conſiderable quantity, notwithſtanding the calcination has been carried on to ſuch a degree, as to deprive the metal of its metallic properties.

The ſulphurated and grey oxyd of antimony urged by heat, without addition, melts into a glaſs of a red brown, or hyacinthine colour. This glaſs is variouſly fuſible, and has different degrees of tranſparency, accordingly as the metal made uſe of was more completely calcined. If the oxyd contain a ſmall proportion of ſulphur, and a larger of oxygen, the glaſs it affords is tranſparent, and leſs fuſible, and is *glaſs of antimony*, or the vitreous ſulphurated oxyd of antimony, properly ſo called. But if the oxyd contain much ſulphur, and ſtill nearly approaches the metallic ſtate, it produces a more fuſible and more opake glaſs; this is called *liver of antimony*, becauſe of its dull red colour, reſembling the liver of animals. When the oxyd of antimony has been calcined ſo perfectly, as that it is difficult to bring it into fuſion, a ſmall piece of ſulphur, or of ſulphure of antimony, may be thrown into the crucible, and the matter inſtantly melts.

The grey oxyd of antimony, and the vitreous oxyd, being heated in a crucible with their own weight of black flux, and a ſmall quantity of black ſoap, or oil, are reduced, and afford the pure antimony. The black flux, in this operation, anſwers two intentions; the alkali which it contains unites to the ſulphur, which has not been diſſipated from the ore by the action of the fire, and the coaly matter favours the reduction of the metallic oxyd. This is the method of preparing, what is called, the *regulus* of antimony in the large way for commercial purpoſes. The regulus is caſt into flat globular pieces, which have a cryſtallization on their ſurface in the form of the leaves of fern.

Antimony is ſcarcely altered by the contact of light. It does not melt till after ignition, and if it be ſtrongly heated in cloſed veſſels, it is entirely volatilized without decompoſition. If it be ſuffered to cool ſlowly when melted, and the fluid portion be poured out after its ſurface is become congealed, the remaining part is found to be cryſtallized in pyramids, or quadrilateral pieces, as we have already obſerved.

This metal melted in open veſſels is quickly oxydated. White thick fumes ariſe, which fall again on the ſurface of the melted metal, or adhere to the cover of the crucible, in the form of ſmall needles. This is a ſublimed metallic oxyd, to which the names of *argentine*, or *ſilvery flowers of regulus of antimony*, or *ſnow of antimony*, have been given. To prepare ſmall quantities, a crucible is placed horizontally in a furnace, ſo that its rim applies to the opening of the furnace to which it is luted with clay. Antimony is put into the crucible, and the fire raiſed ſufficiently to melt it, and cauſe it to emit fumes. The ſmoke being received in a ſecond crucible applied to the firſt, becomes condenſed in very ſlender, white, and brilliant needles, which appear to be quadrangular priſms.

The white and ſublimated oxyd of antimony are not only ſuſceptible of volatization at the time of the deflagration, or burning of the ſemi-metal, but ſublime alone if again urged by a ſtrong heat. This oxyd may likewiſe be melted into an orange-coloured glaſs, paler and more tranſparent than is made with the grey oxyd and ſulphure of antimony. It is likewiſe much leſs fuſible. Antimony is not altered by the action of combuſtible matters, but the oxyds of antimony are decompoſed by ſubſtances of this nature, and reſume the metallic ſtate. As theſe oxyds are highly oxydated, and charged with a large proportion of oxygen, they very difficultly aſſume the metallic ſtate; and as they are likewiſe very volatile, they cannot be reduced but in cloſe veſſels. It appears that the white ſublimated oxyd is ſoluble in water, and poſſeſſes certain ſaline characters. Rouelle is the firſt who made this obſervation, with regard to *flowers* of antimony; and as ſeveral other metallic oxyds, and, in particular, thoſe of arſenic, molybdena, and tungſten, become ſaline and acid when they are ſaturated with oxygen, it may probably be hereafter diſcovered that the oxyd of antimony poſſeſſes the ſame property.

Antimony is ſcarcely at all changed by expoſure to air, it being only obſerved that its ſurface becomes tarniſhed. It is not ſoluble in water, though ſeveral phyſicians have ſuſpected that it communicates an evident emetic quality to that fluid. The white oxyd of antimony, diſſolved in water, communicates an emetic property; this action of the oxyd of antimony, together with its ſolubility in water, and its volatility, ſhows, as we have juſt obſerved, a ſort of analogy between it and the oxyd of arſenic. Many mineralogiſts have hence ſuppoſed that the ore of antimony is never free from arſenic; and it is certain, that this ore in powder, thrown on hot coals, as well as the metal, emits an odour ſenſibly arſenical; and that when the operator has been expoſed during a certain time to this vapour, he experiences its cathartic effects, and other ſymptoms of being ſlightly poiſoned, as I have myſelf ſeveral times obſerved in my laboratory.

Earthy ſubſtances have no action on antimony. Its oxyd enters without difficulty into the compoſition of glaſſes, and gives them an orange colour, reſembling that of the hyacinth.

The action of the ſalino-terreſtrial ſubſtances, and alkalis, on antimony, is not known; but the action of acids on this ſemimetal has been more attended to.

When ſulphuric acid is ſlowly boiled on the regulus, the former is decompoſed, and the latter partly oxydated; a large portion of ſulphureous gas is exhaled, and towards the end a ſmall quantity of ſulphur ſublimes. The maſs remaining after the decompoſition of the acid, conſiſts of much metallic oxyd, and a ſmall proportion of metal, combined with the acid in the ſtate of ſulphat of antimony. The ſaline part may be ſeparated by means of diſtilled water. This ſalt, when brought to a dry ſtate by evaporation, is very deliqueſcent, and cannot be made to afford cryſtals. Fire eaſily decompoſes it; pure water, the ſalino-terreſtrial ſubſtances, and alkalis, likewiſe ſeparate theſe principles. The oxyd of antimony formed by the ſolution and precipitation from the ſulphuric acid, is very difficult of reduction.

The nitric acid briſkly attacks antimony, oxydating a great part, and diſſolving the reſt. This ſolution may be well made in the cold. The ſalt which is produced, being ſeparated from the oxydated part by lixiviation, affords an antimonial nitrat, which is very deliqueſcent, decompoſable by fire, and by the ſame intermediums as the ſulphat of this metal. The oxyd of antimony, formed by the nitric acid, is very white, and is, at the ſame time, exceedingly refractory, and difficult of reduction.

The muriatic acid appears to act with more difficulty on antimony than the other acids; it however diſſolves it by the help of a long digeſtion, and oxydates it leſs than either the ſulphuric or nitric acid. I have obſerved, that when this acid is left for a long time on antimony in powder, it acts ſlowly, and diſſolves a conſiderable quantity. The antimonial muriat, which is obtained in ſmall needles by a ſtrong evaporation, is very deliqueſcent, melts in the fire, is volatilized, and is decompoſed by diſtilled water, like the ſublimed muriat of antimony, named *butter of antimony*, from which it does not ſeem greatly to differ. Monnet, who has well deſcribed this combination, as effected by a conſiderable heat, obſerves, that the combination made with an oxyd of antimony, differs greatly from that which is prepared with the metal, in its fixity and manner of cryſtallizing in laminæ, like ſulphat of lime and boracic acid. This ſalt is beſides decompoſable by water. We have had occaſion to obſerve, that in the ſolutions of the antimony by the muriatic acid, or by means of diſtillation, there is always a ſaline portion which does not riſe by the action of fire, and reſembles that which Monnet makes mention of. This depends on its having been ſtrongly oxydated by the acid. The ſame obſervation applies equally to almoſt all metallic ſolutions which exiſt in different ſtates, accordingly as they contain metals more or leſs burnt or oxygenated. Bergman affirms, that the muriatic acid has a ſtronger affinity with antimony than the other acids have. The oxygenated muriatic acid oxydates antimony with the greateſt facility. Weſtrumb has diſcovered that antimony in powder, when thrown into oxygenated muriatic acid gas, burns rapidly with a white and very brilliant flame.

Aqua regia, or the nitro-muriatic acid, diſſolves antimony more readily than either of the acids which compoſe it. The activity of the muriatic acid is increaſed, on account of its union with the oxygen ſeparated from the nitric acid. Nitro-muriat of antimony is very deliqueſcent, and may be decompoſed like the other ſaline combinations of this metal[a].

Sulphure of antimony, or the natural combination of ſulphur with the metal, is in general more ſoluble, and is leſs oxydated by acids than the metal itſelf. It ſeems as if the ſulphur partly defended the antimony from the action of theſe ſaline ſubſtances. Nitro-muriatic acid has a moderate action on this mineral. It is a very good menſtruum for ſeparating the ſulphur, which precipitates under the form of a white powder. Baumé directs that *aqua regia*, compoſed of four parts of nitric, and one of muriatic acid, ſhould be employed in this operation; but he has not determined the ſtrength of theſe acids. When the action of the acid is over, the ſolution may be filtered, and the ſulphur remains on the filter. The weight of this ſhows the reſpective quantities of ſulphur and antimony contained in the ore. It muſt, however, be obſerved, that the ſulphur, thus ſeparated, is always mixed with a ſmall quantity of the oxyd of antimony; ſo that this experiment cannot be eſteemed as very exact, unleſs the portion of oxyd, mixed with the ſulphur, be previouſly ſeparated by means of acids.

A ſmall portion of *kermes* is formed by the ſolution of ſulphure of antimony in muriatic acid, which proves that the water has been decompoſed.

This metal decompoſes many neutral ſalts. Monnet, in his treatiſe on the Solution of Metals, has deſcribed an operation, by which he ſhows that antimony decompoſes ſulphat of potaſh. He melted in a crucible a mixture of one ounce of this ſalt, and half an ounce of the metal. A yellow, vitriform, exceedingly cauſtic maſs was produced, which was found to be an antimoniated ſulphure of potaſh. This maſs, being waſhed with hot water, afforded, by cooling, a reddiſh ſulphurated oxyd of antimony, or true *kermes*. It will eaſily be underſtood, that, according to the new doctrine, the ſemi-metal ſeizes the oxygen of the ſulphuric acid, which laſt, by that means, is converted into ſulphur. A ſeries of experiments, which I have made on this ſubject, have convinced me, that many metallic ſubſtances are capable of decompoſing ſulphuric ſalts, in the ſame manner as I ſhall ſhow in the following chapters.

Nitrat of potaſh is decompoſed very readily by antimony. When equal parts of this metal and of nitre in powder are thrown by ſmall portions at a time into a red hot crucible, a ſtrong detonation takes place, and the metal is burned by the aſſiſtance of the oxygen afforded by the nitre. After this operation, the crucible is found to contain the fixed alkali or baſe of the nitre, and the antimony in the ſtate of a white oxyd. This oxyd is called *diaphoretic antimony*; we call it *oxyd of antimony by nitre*. Antimony is not uſually employed in this operation, but the native ſulphure of antimony, or its ore; in which caſe, a larger quantity of nitre is required to be added; as for example, three parts to one of this mineral, in order that not only the metal may be burned, but likewiſe all the ſulphur to which it is united. The reaſon why the ore is preferred in this proceſs is, that the ſulphur renders the detonation of the nitre more rapid, and ſingularly facilitates the combuſtion of the antimony.

The matter that remains in the crucible after the detonation, is compoſed of the oxyd of antimony, united partly to the fixed alkali of the nitre, and partly to a portion of the nitre which eſcaped the detonation. It likewiſe contains a ſmall quantity of ſulphat of potaſh, formed by the acid of the ſulphur, and the fixed alkali of the nitre. This compound is called the *ſolvent of Rotrou,* or *unwaſhed diaphoretic antimony.* The matter being thrown into hot water, the ſaline part is diſſolved, and the metallic oxyd remains ſuſpended. The water is poured off before ſubſidence, and the white and fixed oxyd is then ſuffered to fall down; this is called *waſhed diaphoretic antimony.* It muſt be carefully dried, and then moulded into little ſquare pieces. The water, which floats above, holds in ſolution the ſaline matters which were contained in the mixture, and alſo a portion of the metallic oxyd, almoſt acidified, united to the alkali of nitre. This kind of antimoniat of potaſh is ſuſceptible of cryſtallization, according to Berthollet. Acids decompoſe it, and precipitate an oxyd of antimony, called *ceruſs of antimony*, or the *materia perlata* of Kerkringius. The liquor which remains after the precipitation contains a ſmall quantity of nitre which had eſcaped the detonation, a ſmall quantity of ſulphat of potaſh produced during the detonation, and the neutral ſalt formed by the union of the acid to the alkali, which holds the metallic oxyd in ſolution. Though the laſt ſalt varies according to the acid made uſe of, it is very improperly called *antimoniated nitre* of Stahl. This ſalt in general is not nitre, becauſe the ſulphuric or muriatic acids are uſually applied to precipitate the oxyd of antimony; and when the precipitation is well made, no part of the oxyd remains in the ſalt.

The oxyds of antimony obtained by nitre may be melted into glaſs, as well as all the other oxyds of this metal; but as they are in a very perfect ſtate of oxydation, they cannot be fuſed without conſiderable difficulty. For the ſame reaſon, they are not eaſily reduced into metal. They ſeem to be more difficult of reduction than even the oxyd of antimony, made by the fire and ſublimated. It is not yet known whether they be leſs ſoluble in water and in the acids.

Antimony appears capable of decompoſing muriat of ſoda; for if a mixture of theſe two ſubſtances be heated in a retort, ſublimated muriat of antimony paſſes over into the receiver, according to the obſervation of Monnet. This chemiſt has not deſcribed the reſidue of the operation.

This metal does not readily decompoſe muriat of ammoniac, according to Bucquet, and the *butter*, or ſublimated muriat of antimony, is not obtained in this proceſs, as Juncker affirms.

All combuſtible matters act more or leſs on antimony. Hydrogen gas alters its ſurface, and gives it a darker colour. It acts in a much more efficacious manner on its ſolutions. I have cauſed this gas, obtained from iron by diluted ſulphuric acid, paſs through a ſolution of antimony in nitro-muriatic acid. The latter immediately became turbid, and depoſited a yellow orange coloured matter, ſimilar to the *golden ſulphur*; but never reſembling true *kermes*. The oxyds of white antimony, whether dry or moiſtened with water, being expoſed in the ſame manner to the hydrogen gas, did not appear to be at all changed.

Sulphur combines very readily with antimony, and forms an artificial ore, perfectly ſimilar to native ſulphure of antimony. To obtain this combination, equal parts of ſulphur and of the antimony are to be quickly melted in a crucible. A mineral in the form of needles of a dark grey is produced, which never contains ſo much as the half of its weight of ſulphur, unleſs one part and a half of the latter ſubſtance be uſed with one part only of the metal. I have likewiſe obſerved, that one ounce of the antimony melted in a retort, with one ounce of ſulphur, produced ten drachms of ſulphure of antimony, which conſequently did not contain more than two drachms of ſulphur; and that the reſt of this combuſtible matter, ſwelling up by the fuſion, paſſed into the receiver. No more than one part of ſulphur, therefore, is required to give the characters of ore to four parts of the antimony; and hence we may obſerve, how neceſſary it is to make an aſſay of antimony before it is uſed for medical purpoſes, in order that the effect of different ſubſtances combined with this metal may be properly eſtimated.

Alkaline ſulphures, or *livers of ſulphur*, completely diſſolve antimony, and form a yellowiſh maſs, from which antimoniated ſulphur may be precipitated by any acid, which gives it immediately an orange colour. *Hepatic*, or ſulphurated hydrogen gas, acts on the ſolutions of this metal abſolutely in the ſame manner as the hydrogen gas[b].

Antimony unites with arſenic and with biſmuth, but theſe alloys have not yet been carefully examined.

Such are the principal properties of this metal. It is likewiſe neceſſary to conſider its ore, which is improperly called *antimony*. As this mineral is uſed in the preparation of a great number of important remedies, it follows of courſe, that its properties are much better known than thoſe of the metal it contains. The labours of the alchemiſts with this mineral have multiplied our knowledge concerning it, and no ſubſtance has afforded materials for a greater number of experiments than ſulphure of antimony. We have already ſeen, that by means of heat, a portion of the ſulphur may be ſeparated; that a grey oxyd reſults from this operation, which may be melted into *glaſs*, or *liver* of antimony, accordingly as its calcination has been more or leſs perfectly performed. That nitre, at the ſame time that it burns the ſulphur, likewiſe oxydates this metallic matter. But roaſting, and combuſtion by the addition of nitre, are not the only means of ſeparating the ſulphur from antimony. This may be done by preſenting to the mineral a body which has a ſtronger affinity with either of its component parts than that part has to the other.

We have an inſtance of this kind of decompoſition, in applying acids to crude ſulphure of antimony. Theſe ſalts, and eſpecially nitro-muriatic acid, diſſolve the metal, and ſeparate the ſulphur which then floats above. The metal appears to be more eaſily and completely diſſolved when in ſulphure of antimony than when it is pure, as has been before remarked. Iron, and ſome other metallic ſubſtances, deprive the antimony of its ſulphur.

Nitre is employed with ſucceſs in preparing, with ſulphure of antimony, many valuable medicines. We have already ſeen, that when one part of this ore is detonated with three parts of nitre, the ſulphur and the metal are burned, and the reſidue is an metallic oxyd of antimony almoſt acidified, mixed with alkali. If equal parts of nitre and ſulphure of antimony be detonated together, the detonation is of courſe weaker. For this reaſon it is neceſſary to throw the mixture by ſpoonfuls into a red hot crucible; whereas the other proportion uſed in the making of the white oxyd, or *diaphoretic antimony*, need only be once ſet on fire, when it continues to detonate till it is entirely reduced to a white maſs. When the detonation of the antimony and nitre, mixed in equal parts, is finiſhed, the fire is increaſed ſo as to melt the whole; and inſtead of a *diaphoretic* antimony, a brown opaque brilliant brittle maſs is found in the crucible, which is glaſs of antimony covered with ſcoriæ. In this operation the nitre is not ſufficient in quantity to burn all the ſulphur; the remainder therefore holds an oxyd of antimony in ſolution. When the mixture is not heated ſufficiently to melt it, nothing is obtained but a vitreous ſcoria, to which the name of *falſe liver of antimony of Rulland* is given. This matter reduced into powder, and waſhed with water, forms *crocus metallorum;* which is merely oxyd of vitreous antimony pulverized and ſeparated from the ſaline matters produced by the detonation of the nitre.

There are two other preparations analogous to the foregoing, which are true glaſſes of ſulphurated antimony; the one is the ruby of antimony, or *magneſia opalina*, made by melting together equal parts of decrepitated muriat of ſoda, nitre, and ſulphure of antimony. This fuſion, which takes place without detonation, affords a vitreous maſs of a brown colour, very brilliant, and covered with white ſcoriæ. The other, improperly called the *medical regulus*, is prepared by fuſing a mixture of fifteen ounces of ſulphure of antimony, twelve ounces of decrepitated muriat of ſoda, and three ounces of tartar. The reſult is a black ſhining very opaque denſe glaſs, not at all metallic in its appearance. Theſe two compounds, which differ from the true *liver of antimony* in certain extraneous properties, doubtleſs owe this difference to the marine ſalt which enters into their preparation, and whoſe effect on the mineral has not yet been aſcertained.

When antimony is required to be prepared from its ore in the ſmall way in laboratories, no more nitre ſhould be made uſe of than is neceſſary to burn the ſulphur, and a ſubſtance capable of aſſiſting in the reduction of that part of the metal which has been oxydated during this proceſs muſt be added. With this intention, eight ounces of ſulphure of antimony in powder, ſix ounces of tartar, and three of nitre, are taken. Theſe are mixed very accurately, and thrown by ſpoonfuls into a red hot crucible. The nitre detonates with the tartar and the ſulphure of antimony; black flux is formed, and the antimony melts and flows to the bottom. When the matter is well melted, it is to be poured into an iron cone, greaſed and made hot. The cone muſt be ſtruck ſeveral times during the pouring of the mixture; after which, the whole being ſuffered to cool, the regulus of antimony is found at the bottom. The metal is covered with black and reddiſh ſcoriæ, which rapidly attract the humidity of the air. When the *regulus* is pure, its upper ſurface is convex, and preſents the regular figure of a ſtar, which the exalted imagination of the alchemiſts led them to attribute to various cauſes. But it depends ſimply on the manner of cryſtallization of the metal during its cooling. The cooling begins at the ſides, and the fluid matter being preſſed out from the centre towards the circumference, produces this appearance, which takes place only when the maſs of antimony is ſmall; for in the large maſſes of this metal, the undulation of the fluid matter reſpects ſeveral centers, and inſtead of a ſtar, it is found marked with impreſſions in the form of leaves of fern, whichcr yſtallizes under different angles. Reaumur has ſhown, that a ſudden cooling prevents this kind of cryſtallization in the form of a ſtar; and that if one ſide of the cone be quickly cooled, no more than half a ſtar will be ſeen *. The quantity of metal obtained by this proceſs, does not amount to the half of the ſulphure of antimony made uſe of, though this mineral often contains more regulus of antimony than ſulphur.

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* There is doubtleſs a relation between the manner in which metallic buttons cryſtallize at their ſurface, and the form which they affect, when by careful cooling, and a ſeparation of the fluid portion, they are diſpoſed in ſingle cryſtals. The Abbé Mongez is buſied in inquiring into this relation in his reſearches on the cryſtallization of metals.—F.

This is cauſed by a portion of the metal combining with the ſaline matters which form the ſcoriæ.

The ſcoriæ, which flow above the antimony extracted by this proceſs, are of a very compound nature. They contain the fixed alkali of the nitre, and of the tartar united to the ſulphur of the antimony, and in the ſtate of an alkaline ſulphure or *hepar*. This ſulphure holds a portion of the oxyd of antimony in ſolution, and is beſides mixed with a ſmall quantity of ſulphat of potaſh, formed by the ſulphuric acid produced in the combuſtion of the ſulphur, and united to a portion of the alkali of the nitre. Beſides which, they contain a coaly matter afforded by the tartar. If theſe ſcoriæ be boiled in a large quantity of water, and the hot liquor be filtered, the coaly portion remains on the filter, and the liquid, which is clear while it continues hot, becomes troubled by cooling, and depoſits a reddiſh matter, which has been hitherto conſidered as an antimoniated ſulphure of potaſh. The precipitate is called *kermes mineral* by the dry way. When the liquid affords no more, it may be evaporated, and a matter leſs coloured than the *kermes* is obtained, or true antimoniated ſulphure of potaſh. It likewiſe affords ſulphat of potaſh. If, inſtead of evaporating the liquid, any acid be poured in, a yellow orange precipitate of ſulphurated oxyd of antimony, called the *golden ſulphur of antimony*, is produced, which does not appear to differ much from the *kermes*.

If ſulphure of antimony, broken into ſmall pieces, be boiled for a ſhort time in water charged with carbonat of potaſh or of ſoda, theſe alkalis diſſolve the ſulphur of the antimony, and form an alkaline ſulphure, which holds a part of the oxyd of antimony in ſolution. This boiling liquor being filtered, and ſuffered to cool, the portion of red ſulphurated oxyd of antimony or *kermes* which it contains precipitates; and the cold liquor being filtered, the orange coloured ſulphurated oxyd of antimony may be precipitated anew by means of acids. If an alkaline lixivium be boiled again on the reſidue of the antimony, more *kermes* may be obtained, but this *kermes* is paler than the foregoing; and the oftener the operation is repeated, the leſs true *kermes* is afforded. The alkali appears to diſſolve more ſulphur than oxyd of antimony, and the mineral ſhould not be boiled more than once or twice. This operation is called in general the preparation of *kermes* by the humid way.

The name of *kermes* was given to this preparation by a Chartreux friar named Simon, doubtleſs on account of its colour, which reſembles that of the animal called kermes*, which is employed in dying. Kermes mineral has likewiſe been called *Poudre des Chartreux*, becauſe it was firſt prepared by perſons of that religious order. The diſcovery of this medicine is due to Glauber, who prepared it with ſulphure of antimony, and a ſolution of nitre fixed by coal; but he has deſcribed his proceſs in an unintelligible manner, and almoſt entirely under alchemiſtical emblems. Lemery, who laboured much with antimony, and who has given us a preparation analogous to *kermes*, under another name, may be regarded as the true inventor. This remedy, however, was offered to the public as an entirely new invention many years after the publication of the works of that chemiſt, and, in fact, owes its celebrity to the ſingular cures effected by means of it in the hands of brother Simon. This friar had the compoſition from a ſurgeon named La Ligerie, who was not himſelf the inventor. This laſt affirmed that he received it from Chaſtenay, lieutenant in the army at Landau, to whom it had been communicated by an apothecary, who pretended to be a diſciple of Glauber. Dodart, then firſt phyſician to the king, applied to La Ligerie to publiſh the receipt of *kermes*, which he accordingly did in the year 1720. Lemery the younger claimed the diſcovery in the name of his father in the Memoirs of the Academy, and with great juſtice, as moſt chemiſts ſtill make uſe of the proceſs invented by him for the preparation of this remedy.

The proceſs deſcribed by La Ligerie conſiſts in boiling for two hours a pint of rain water, with four ounces of the liquor of nitre fixed by charcoal, and a pound of ſulphure of antimony broken into ſmall pieces. The boiling liquor is filtered, and the ſame ore is again boiled with three ounces of freſh lixivium diluted in a pint of rain water. Laſtly, The ſecond reſidue is boiled a third time with the preceding lixivium; two ounces of liquor of fixed nitre, and a pint of rain water being added. It is then filtered, and the *kermes* ſuffered to ſettle, which being waſhed till it is inſipid, is then dried; and, laſtly, after ſpirit of wine has been burned upon it, it is reduced to powder. This proceſs is very long, and affords but a ſmall quantity of *kermes*, not more than two or three drachms from a pound of ſulphure of antimony. It is, moreover, very troubleſome, on account of the long ebullition, and the evaporation of the water. Laſtly, It occaſions a loſs of more than three quarters of the ore of antimony, on account of the ſmall quantity of alkali employed in proportion to that of the mineral.

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* The animal *kermes*, or *ſcarlet grain*, uſed in dying, is the ſkin of a female inſect, which fixes on the holm or ilex, and becomes extended by degrees in the manner of a ſmall cap or button; it has loſt the form of rings, by which theſe animals are known: it is beneath this cap that the eggs it contains are encloſed. The inſects pierce the ſhell, and iſſue out, and the females, not having wings, fix and die on the leaves of the tree, after having been fecundated by the males, who have wings. Cochineal is another ſpecies of inſect ſimilar to this, as we ſhall ſhow in our account of the animal kingdom.—*Fourcroy.*

Baumé, who adopted the proceſs of Lemery, gives two methods for the eaſy preparation of a large quantity of the red ſulphurated oxyd of antimony or *kermes* in a ſhort time; the one by the dry, and the other by the humid way. According to the firſt method, one pound of ſulphure of antimony is melted in a crucible, together with two pounds of very pure ſalt of tartar, and one ounce of ſulphur, the whole being previouſly well pulverized. This melted mixture is poured out into an iron mortar, is pulverized groſsly when cold, and is then boiled in a ſufficient quantity of water. The liquor being filtered through paper, affords a *kermes* of a red brown in cooling, which, being firſt waſhed with cold, and afterwards with boiling water, till it is deprived of all ſaline matter, is dried, pulverized, and paſſed through a fine ſieve.

To prepare the *kermes* by the humid way, according to the ſame chemiſt, a lixivium of five or ſix pounds of cauſtic fixed alkali is boiled with fifteen or twenty pounds of river water. Four or five ounces of ſulphure of antimony, previouſly levigated, is thrown into this boiling liquor, and the mixture being well agitated, and ſuffered to boil for a very ſhort time, is poured on the filter. This liquor depoſits much *kermes* during its cooling, which is to be waſhed in the ſame manner as the *kermes* produced by fuſion. According to Baumé, this laſt proceſs affords twelve or thirteen ounces from a pound of antimony, and he aſſures us that the two kermes are perfectly ſimilar.

The theory of this operation, and the nature of kermes, are not yet perfectly known, notwithſtanding the labours of many celebrated chemiſts. It is generally thought that the alkali diſſolves the ſulphur of the ore, and that the ſulphure it forms diſſolves the antimony. This metal, however, is not totally diſſolved, ſince in the proceſs of Lemery by the humid way, a grey powder is precipitated during the ebullition, which may be melted without addition into true antimony. The precipitation of the kermes by the cooling of the lixivium, which is at firſt reddiſh and tranſparent, but loſes its colour in proportion as the kermes is depoſited, is a phenomenon ſtill more ſingular. This compound is by others thought to be a kind of antimony, with an over doſe of ſulphur, and ſoluble in the hot alkaline lixivium. In fact, if the alkaline lixivium be heated on a certain quantity of kermes ready prepared, a complete ſolution will take place. The lixivium, which has depoſited kermes by cooling, ſtill contains antimoniated ſulphure of pot-aſh; by the addition of an acid, an orange coloured matter is thrown down, called *golden ſulphur of antimony*, which is much more emetic than the kermes, and is ſuppoſed to contain a leſs proportion of ſulphur, and more of the metallic oxyd.

Geoffroy, who communicated to the Academy, in the years 1734 and 1735, ſeveral memoirs concerning the kermes mineral, made a great number of experiments with the intention of analyzing it. The action of acids is eſteemed the moſt efficacious means that can be employed for that purpoſe. It is thought that theſe ſalts diſſolve the metal, and leave the ſulphur diſengaged, and that the reſpective quantities of theſe two ſubſtances can be thence eſtimated. One drachm of kermes, according to Geoffroy, contains ſixteen or ſeventeen grains of the metal, thirteen or fourteen grains of fixed alkali, and forty or forty-one grains of ſulphur. Many chemiſts at preſent think that the kermes does not contain an atom of alkali. Baumé affirms, that this ſalt is not one of its conſtituent principles, and that it may be entirely deprived of it by ſimple waſhing in a large quantity of boiling water. Deyeux, who has likewiſe made experiments on this ſubſtance, is of the ſame opinion. I have had occaſion to make the ſame obſervation in a ſeries of experiments made in conjunction with the La Rochefoucault. But the moſt important circumſtance relative to the kermes is, that it appears to be a very different ſubſtance, according to the ſeveral circumſtances attending its preparation. It contains ſulphur and metal in various proportions; and there is reaſon to apprehend that its effects muſt vary exceedingly, according as the proportion of theſe ſubſtances differ. In general, it ſeems that the ſtate of the ſulphure of antimony, the variety of the proportions of its component parts, its greater or leſs diviſion, the more or leſs cauſtic ſtate of the alkali and its quantity, the quantity of the water, the time of ebullition, and many other analogous circumſtances, occaſion ſingular variations in the nature of kermes. In order that it may be the ſame in all caſes, it ought to be prepared with ſubſtances always of the ſame quality, and in circumſtances perfectly ſimilar. Without entering into any very long details concerning the phenomena the kermes has preſented, when treated by a great number of intermedia, I ſhall only add, firſt, That cauſtic alkalis greatly alter it, and diſſolve it even in the cold. Secondly, That acids act with very different degrees of force on this ſubſtance, and that it is exceedingly difficult to determine with accuracy, by means of acids, the quantity and the ſtate of the metal or of the ſulphur which enter into its compoſition, becauſe the ſulphur which is ſeparated always retains a certain quantity of the oxyd of antimony.

Cauſtic alkalis act much more ſtrongly on ſulphure of antimony than mild alkalis, and produce a much greater quantity of kermes of a deep colour. Lime, or lime-water, digeſted on antimony in powder, affords, even without heat, in a certain number of days, a kind of kermes, or golden ſulphur, of a beautiful red colour. Ammoniac alters it in the ſame manner. When muriat of ammoniac is diſtilled with ſulphure of antimony, a pulverulent ſublimate of a purple colour is obtained, which appears to be a kind of antimoniated ſulphure with baſe of ammoniac.

To conclude the hiſtory of the decompoſition of ſulphure of antimony, we ſhall add, that many metallic ſubſtances have the property of depriving it of its ſulphur, by their ſtronger affinity to that ſubſtance. Tin, iron, copper, and ſilver, produce theſe decompoſitions. Tin or ſilver, being melted together with this ore, unite with the ſulphur, and leave the antimony. Iron and copper produce the ſame effect, provided they be firſt reduced to filings, or very ſmall parts, and be previouſly made red hot before the ſulphure of antimony is added. The mineral accelerates the fuſion of theſe metals, and the brittle metal is ſeparated. The metal obtained by theſe proceſſes is not pure, but retains a portion of the metallic ſubſtance made uſe of to ſeparate the ſulphur. Its colour and appearance always indicate its impurity; it is diſtinguiſhed according to the names of the metals to which it is united.

Antimony is employed in many arts, and eſpecially by the type makers. It was formerly uſed as a purge. Wine or water was poured into veſſels made of this metal, and ſuffered to ſtand for the ſpace of a night, and the following day the liquor was drank: but as variations of the temperature of the place in which this operation was made, and of the acidity of the wine made uſe of, muſt have neceſſarily produced differences in the quantity of metal taken up, it is with juſtice that this medicine was abandoned, as not being to be depended on. For ſimilar reaſons, the perpetual pills, or ſmall balls of this metal, which were ſwallowed as purges, have been renounced. The ſtate of the digeſtive juices, the nature of the mucus in the firſt paſſages, and the ſenſibility of different individuals, muſt have rendered their effects uncertain, and often dangerous.

Crude ſulphure of antimony, Rotrou's ſolvent, oxyd of antimony, called *diaphoretic*, kermes mineral, and the golden ſulphur, are the only antimonial medicines at preſent uſed *. Sulphure of antimony is employed as a ſudorific in cutaneous diſorders. It is ſuſpended in a linen bag in the veſſels in which the ptiſans appropriated to theſe diſorders are prepared; but many phyſicians deny it to have any virtue when adminiſtered in this manner. It is likewiſe taken in ſubſtance, being firſt finely levigated, and made up into pills for the ſame purpoſe.

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* Many other antimonial preparations are in common uſe in Britain, for which ſee the Diſpenſatory. T.

The ſolvent of Rotrou, or the alkaline oxyd of antimony, is greatly recommended in lymphatic diſorders, produced by the congelation of that liquid, as in ſcrophulous affections, and in general in all glandular tumours. Many phyſicians have no confidence in the effects of waſhed diaphoretic antimony. They conſider this medicine as a pure oxyd of antimony, without any virtue whatſoever. We cannot, however, forbear obſerving, that this oxyd, in which Rouelle the younger has obſerved a remarkable degree of ſolubility, may produce ſingular effects in conſequence of this property. It is likewiſe certain, that as the action of the gaſtric and inteſtinal juices on metallic oxyds are not known, it cannot therefore be determined whether a ſubſtance inſoluble and inſipid to all appearance has any virtue or no. Obſervation, however, teaches us, that this medicine produces but ſlight effects in eruptions, and in the moſt obſtinate diſorders of the ſkin, though employed for a long time. The unwaſhed diaphoretic antimony, or ſolvent of Rotrou, which is much more active than the before-mentioned preparation, by reaſon of the alkali it contains, deſerve to be preferred. In theſe affections a medicine, called *Poudre de Chevalleray*, is uſed. It is diaphoretic antimony, calcined ſeven times ſucceſſively during the ſpace of two hours, with freſh nitre each time, and lixiviated after each operation. It does not ſenſibly differ from the waſhed diaphoretic antimony, becauſe the metal, once well oxydated, as it is when detonated with three times its weight of nitre, cannot be further oxydated, and for that reaſon in this preparation no ſucceeding detonation takes place. The preſent medicine is obſerved to be abſolutely ineffectual when deprived of the alkali.

Kermes mineral is one of the moſt valuable antimonial remedies we are in poſſeſſion of; it is attenuating, and is employed with the greateſt ſucceſs in pituitous affections of the ſtomach, the lungs, the inteſtines, and even the urinary paſſage. It is moſt commonly uſed in diſorders of the breaſt to aſſiſt expectoration. It ought not, however, to be adminiſtered, till after the inflammation is abated. It has likewiſe great ſucceſs when given in repeated ſmall doſes in catarrhs of the breaſt, the humid aſthma, maladies of the ſkin, glandular ſwellings, &c. It is adminiſtered in a doſe from half a grain to two or three grains in proper liquids, or made up in pills. It ſometimes cauſes vomiting, and very frequently acts as a ſudorific or a diuretic.

The golden ſulphur, on account of its being a violent emetic and cathartic, is not much uſed. It was formerly given in the ſame diſorders as the kermes, but its effects are much more uncertain.

There are alſo many other preparations of antimony, which are uſed in medicine to great advantage; but as they are made up with vegetable matters, we ſhall ſpeak of them in another part of this work. This metallic ſubſtance is one of the moſt important in the Materia Medica, and phyſicians cannot pay too great an attention to its properties. It is one of thoſe upon which the alchemiſts, and even the chemiſts, have beſtowed great labour, which has given riſe to the numerous preparations above deſcribed.

NOTES ON CHAPTER XIII.

ANTIMONY.

[a] Fluoric acid diſſolves only a very ſmall quantity of the oxyd of antimony.

The boracic acid ſeems likewiſe to have but a weak affinity for this metal.

The phoſphoric acid forms a greaſy ſaline maſs with oxyd of antimony. This greaſy maſs is changed into a tranſparent glaſs in the fire.

Oxalic acid forms with antimony a ſalt very inſoluble in water. This acid diſplaces the ſulphuric, nitric, and muriatic acids, from their combinations with antimony.

The acetic acid diſſolves oxyd of antimony; but the ſalt which they form does not cryſtallize by evaporation.

The ſuccinic acid diſſolves the oxyd of antimony very ſparingly. The ſalt which they form is little known.

Arſenic acid diſſolves antimony by heat with ſome difficulty. The ſalt which they form is decompoſed by dilution with water. The precipitate ſeems to be a combination of the oxyds of the two metals. If arſenic acid be diſtilled in the dry way with antimony, metallic arſenic and oxyd of antimony riſe in ſublimation.

The citrat and malat of antimony are unknown.

Benzoic acid diſſolves readily the oxyd of antimony, and forms with it a white foliated maſs, which is ſoluble in water and ſpirit of wine, and which remains dry in the atmoſphere.

Pruſſiat of alkali precipitates antimony from its ſolutions in acids of a white colour.

The gallic acid forms with it a grey-bluiſh precipitate.

The carbonic acid ſeems to have no direct action either on the metal or the oxyd of antimony.

The fixed alkalis ſeem to diſſolve a little oxyd of antimony in the moiſt way. In the dry they act ſtrongly on this oxyd. Ammoniac alſo diſſolves the oxyd of antimony.

b Phoſphure of antimony is prepared by melting in a covered crucible equal parts of the vitreous phoſphoric acid and pulverized antimony with 1-16th of charcoal duſt. The maſs formed has a metallic luſtre and a foliated fracture. It melts in the fire, and burns with a green flame. During combuſtion the white oxyd of antimony is ſublimed.

Antimony unites by fuſion with gold, and renders it pale and brittle. It may be ſeparated from gold by a violent heat in the form of a white ſublimate. Antimony precipitates gold from its ſolution in aqua regia, but it falls along with the gold in the ſtate of an oxyd.

Platina and antimony combine eaſily together. The mixture is hard, brittle, and fine grained. It is difficult to free the platina from this metal again, for it becomes infuſible in proportion as the antimony is ſeparated. Platina is precipitated from aqua regia by antimony, but the antimony falls down along with it in the form of an oxyd.

Silver melts eaſily with antimony, and forms with it a very brittle mixture. Antimony precipitates ſilver from nitric acid. Silver takes ſulphur from the ſulphure of antimony by fuſion.

Mercury does not amalgamate eaſily with antimony. Diſtilled with cinnabar, the antimony unites with the ſulphur, and allows the mercury to paſs over into the receiver. If three parts of antimony, with eight of oxygenated muriat of mercury, be diſtilled together, the muriat, uſually termed *butter* of antimony, paſſes over into the receiver, and the reduced mercury, with ſome antimony, remains in the retort. If inſtead of the metal, ſulphure of antimony be uſed in this proceſs, cinnabar will be ſublimed into the neck of the retort.

Lead and antimony form by fuſion a brittle maſs. It is a mixture of this kind which is uſed for type making, in the proportion of 80 parts of lead, to from 25 to 15 of antimony. Lead has the ſtrongeſt affinity for acids, and takes by fuſion the ſulphur from ſulphure of antimony.

Biſmuth and antimony form a brittle maſs. Biſmuth has the ſtronger affinity for acids, and takes ſulphur by fuſion from the antimonial ſulphure.

Antimony forms a lead-coloured mixture with nickel. It has a leſs affinity than nickel for acids and ſulphur.

Copper becomes pale and brittle by its union with antimony. It precipitates antimony from acids, and takes by fuſion ſulphur from the ſulphure of antimony.

Arſenic forms a brittle maſs with antimony. The oxyd of arſenic melts with it into a flux.

Iron melts with antimony into a hard white brittle maſs. The antimony may be ſeparated from this combination by fire, or by ſolution in aqua regia, and ſubſequent dilution with water. Iron having a ſtronger affinity for ſulphur than antimony, is commonly uſed to free it from that ſubſtance.

Cobalt and antimony form by fuſion a brittle maſs. The cobalt has the ſtrongeſt affinity for acids and ſulphur.

Tin melts with antimony into a white brittle mixture. Antimony is uſed in the arts to harden tin. It yields to tin in its affinities for acids and ſulphur.

Zink forms with antimony a brittle maſs. In precipitating antimony from aqua regia, a portion of the oxyd of zink falls along with it. The zink has an inferior affinity for ſulphur. See *Gren's Handbuch Spieſglanz metall.*

CHAPTER XIV.

CONCERNING ZINK.

Zink is a brilliant blueiſh white metallic ſubſtance, cryſtallized in narrow plates. It has neither taſte nor ſmell. It cannot be reduced into powder like the other metals, but becomes flattened under the hammer, and may even be laminated, provided it has not previouſly been too much hammered. This experiment was made by Sage. When it is required to have zink in a ſtate of extreme diviſion, it muſt be granulated, that is to ſay, poured melted into cold water, or elſe reduced into filings. It has the inconvenience of choking up the files. Macquer affirms, that when heated nearly to melting, it becomes very brittle, and may then be pulverized. This property is very different from that of the metals, which become more ductile by the action of heat, and affords an advantageous proceſs for obtaining zink in a ſtate of extreme diviſion. It may likewiſe be obtained in this ſtate, by triturating it while melted, and keeping its particles aſunder by continual motion, before they take the ſolid form by cooling. This operation muſt not be made in an iron mortar, becauſe zink always diſſolves a portion of this metal; a mortar and peſtle of marble muſt be uſed.

Zink loſes about one ſeventh of its weight by immerſion in water. The particular facets which the pieces of zink met with in commerce preſent in their fracture, prove that this metal has the property of cryſtallizing in a peculiar manner. Mongez has ſucceeded perfectly in his attempts to obtain this cryſtallization. It is compoſed of bundles of ſmall quadrangular priſms, diſpoſed in all directions, and of a blue changeable colour, if expoſed to air while the metal is ſtill hot.

Sage conſiders zink as the moſt common of all the metals after iron. He affirms that he found it in all the martial pyrites; and Grignon affirms that the *cadmia fornacum*, obtained from the earthy ores of iron, contains much zink.

Native zink is very rare; moſt naturaliſts doubt whether it exiſts at all; yet Valmont de Bomare affirms, that he ſaw in the mines of lapis calaminaris, in the duchy of Limbourg, and in the mines of Goſlar, ſpecimens of this in ſmall flexible fibres of a greyiſh colour, and eaſily taking fire.

This metal is moſt commonly found in the ſtate of an oxyd. It then conſtitutes *lapis calaminaris*, which has a great variety of forms. It is ſometimes cryſtallized in cubes, in priſms, in leaves, or in plates; but moſt commonly it is in irregular maſſes. Its colour is likewiſe ſubject to variations. In ſome ſpecimens it is white, in others grey and yellow, and in others reddiſh. Though very hard, it is never ſufficiently ſo to give fire with the ſteel. It is found in quarries of conſiderable extent in the duchy of Limbourg, the counties of Namur, and of Nottingham and Somerſet in England. Marine ſubſtances, calcareous ſpar, &c. are often met with in calamines, which proves that they have been formed by a ſubſidence from water. The lapis calaminaris is likewiſe called *natural or foſſil cadmia.* Bergman, who has made a moſt extenſive inquiry into the analyſis of the ores of zink, found in almoſt all calamines, ſiliceous earth, alumine, and oxyd of iron, in different proportions; the calamines contain from four to thirty hundredth parts of metal. The Abbé Hany has diſcovered the electric property of tourmalins in all cryſtallized calamines. The zeolite formed calamine, the analyſis of which has been given by Pelletier in the *Journal de Phyſique* exiſts in ſmall plates, which has no reſemblance to zeolite. It is becauſe this ſubſtance forms a jelly with acids that mineralogiſts have improperly confounded it with true zeolite.

Zink united to ſulphur forms *blende* or *falſe galena.* This ſulphure of zink is ordinarily diſpoſed in ſcales. Sometimes it appears cryſtallized in tetrahedral, octahedral, and dodecahedral figures. Its colours are various. In ſome ſpecimens it reſembles that of lead, but moſt commonly it is black or reddiſh. A yellow and tranſparent ſort is found at Ronſberg in Norway, at Goſlar, and Sainte-Mariæ. Some blends are phoſphoric when rubbed in the dark. There are ſome which have this property in ſo high a degree, that the ſtroke of a toothpick acroſs their ſubſtance is ſufficient to ſhow it. Blende has been called by the name of *ſterile nigrum*, becauſe when it has been melted to obtain the lead it appeared to hold, nothing was obtained; the zink having been driven off in conſequence of its volatility. All blendes, when rubbed or diſſolved in an acid, give out a very ſenſible ſmell of ſulphurated hydrogen gas. Cronſtedt conſiders this ore as zink united to ſulphur by the intermedium of iron. Sage thinks that it contains an earthy ſulphure, or liver of ſulphur.

Zink is likewiſe found in the ſaline ſtate combined with the carbonic and ſulphuric acids. The firſt of theſe natural compounds is known by the name of *vitreous ore of zink*, or *zink ſpar*. This ore is white, grey, or blueiſh; gives fire with ſteel, is heavy, ſometimes cryſtallized; alſo in ſtalactites or amorphous; it diſſolves with effervefcence in acids, and affords carbonic acid. According to Bergman, one hundred grains contain ſixty-five of oxyd of zink, twenty-eight of carbonic acid, ſix of water, and one of iron.

Sulphat, or native *vitriol* of zink, is found in rhomboidal cryſtals, and in white ſtalactites; it is often cryſtallized in fine needles, or ſilky fibres, reſembling amianthus. In this ſtate it is ſometimes confounded with plume-alum. It is found in Italy, and in the mines of Goſlar, in the Hartz. The zink ores may be diſpoſed in the following manner, according to the ſtate in which the metal exiſts.

STATE I.

Native Zink in flexible, greyiſh, and inflammable fibres.

STATE II.

Oxyd of Zink; Calamine.

Varieties.

1. Oxyd of zink, or white *calamine*, in long tetrahedral priſmatic cryſtals, grouped confuſedly; it ſometimes is greeniſh.
2. Oxyd of zink, or *calamine*, cryſtallized in quadrangular pyramids ſimilar to the dogs-tooth-ſpar, of a white grey, greeniſh, or reddiſh colour. Sage and Romé de Liſle think, that while this calamine is depoſited, the calcareous ſpar is decompoſed; it is often found, in fact, partly calcareous, and hollow in its internal parts.
3. Oxyd of zink, or *calamine ſolid*, and, as if worm-eaten; it

is furrowed, cellular, and cryſtallized, as it were, in dendrites.

4. Oxyd of zink, compact and ſolid *calamine;* lapis calaminaris. That which is obtained from the county of Namur is always calcined; it is not allowed to be exported, without previouſly ſubjecting it to this operation.
5. Oxyd of zink, or *calamine,* in greeniſh or yellowiſh ſtalagmites.
6. Oxyd of zink, or zeolitiform *calamine,* known by the name of Zeolite of Friburg. Pelletier has diſcovered, that this pretended zeolite, of a pearl colour, contains in one hundred parts, from forty-eight to fifty-two, of ſilex, thirty-ſix of the oxyd of zink, and eight or twelve of water.

STATE III.

Zink mineralized by Sulphur, Sulphure of Zink; *Blende.*

The principal varieties of this ore of zink are to be diſtinguiſhed by their diverſities of form. Cubic blende has been ſo named from a fallacious appearance. The following are the principal varieties of form which it aſſumes, according to L'Abbé Hany.

Varieties.

1. Dodecahedral blende, with rhombic facets. This is the primitive form which is obtained from a very accurate ſubdiviſion of the cryſtals. It has not yet been found in nature without additional facets.
2. Blende with twelve trapezoides and twelve triangles.
3. Blende in regular octahedrons.
4. Blende in regular tetrahedrons.
5. Beſides theſe five varieties, conſidered by mineralogiſts as ſpecies, there are others diſtinguiſhed by colour; the blueiſh grey with a metallic aſpect, the black, the red, or reddiſh brown, the yellowiſh green, the waxen yellow, &c. They are all either ſhapeleſs or cryſtallized.
6. Blendes may alſo be diſtinguiſhed by the greater or leſs degree of phoſphoreſcence excited by friction, by the fœtid ſmell of ſulphurated hydrogen which they emit when heated or rubbed.

7. Sulphure of zink, or blende in a ſtate of decompoſition, the plates of which are ſeparated, and their luſtre deſtroyed. This paſſes to the ſtate of oxyd of zink, or of calamine.

STATE IV.

Saline Zink.

Varieties.

1. Carbonat of zink, ſpathoſe zink, or vitreous ore of zink.
2. Sulphat of zink in rhomboidal cryſtals, in ſtalactites, or in fibres of a ſilky appearance.

To make an aſſay of *calamine*, nothing more is neceſſary in general than to pulverize and mix it with charcoal, and to heat it in a crucible covered with a plate of copper; the latter becomes yellow, and is converted into braſs. Bergman has made a much more perfect analyſis of calamines by the humid way. He applied the ſulphuric acid to decompoſe pure calamines, and the carbonat of zink. The ſolution contained ſulphat of zink and ſulphat of iron. He decompoſed the latter by a known weight of zink, and precipitated it afterwards by carbonat of ſoda. He finds, by experiment, that one hundred and ninety-three grains of this precipitate contain one hundred grains of zink. From the weight of the precipitate he deducts the weight of the zink employed to precipitate the iron.

Moſt *calamines* being more compounded than thoſe here mentioned, and containing ſilex, alumine, and lime, combined with the oxyds of zink, iron, and even lead, Bergman firſt treats them three ſucceſſive times with twice their weight of nitric acid each time. By heating the maſs to dryneſs, the acid oxydates the iron, and renders it inſoluble. He afterwards diſſolves the ſoluble part in additional nitric acid, the iron, the ſilex, and the alumine remaining behind. The acid takes up the lime, the oxyds of zink and of lead: muriatic acid is employed to precipitate the latter; the ſulphuric acid to ſeparate the lime, and the zink is laſt of all precipitated by alkaline pruſſiats. The fifth part of the weight of this precipitate he takes to expreſs the zink contained in the *calamine*. He likewiſe employs a ſecond method; ſulphuric acid is diſtilled from calamine to dryneſs, the reſidue is afterwards lixiviated in warm water; from this lixivium he precipitates the iron and alumine by cauſtic ammoniac; the oxyd of zink remains ſuſpended in the ſolution of ammoniacal ſulphat.

The aſſay of *blendes*, after previous roaſting, was formerly made in the ſame manner as *calamines*; Monnet is the firſt who affirmed that they might be conveniently aſſayed by ſolution in aqua-fortis, which unites to the metallic ſubſtance, and ſeparates the ſulphur. The oxyd of zink is ſeparated from the nitric acid by diſtillation. Bergman has made the ſame accurate experiments on theſe ores as on the calamines, and has greatly improved on Monnet's method of the humid analyſis. He firſt ſeparates the water, the arſenic, and part of the ſulphur they contain, by diſtillation; next he treats them with different acids, accordingly as theſe act more or leſs upon their contents, and precipitates the ſolutions by different re-agents.

The ores of zink are not worked for the purpoſe of gaining this metal. It is obſerved, during the ſmelting of lead ores mixed with blende, that the zink is ſublimed in the chimneys of the furnaces, in the form of an oxyd, and produces greyiſh incruſtations, named *tuttia* or *cadmia fornacum*. Another portion is obtained in the metallic form, by cooling the anterior part of the furnace (la chemiſe). The zink being driven up in the vapourous form by the action of the fire, is condenſed in this place, and falls in ſmall grains into powder of charcoal, which covers a ſtone (aſſiette du zink) placed below. This metal is preſerved from oxydation by the powder of charcoal, and is afterwards melted in a crucible, and run into moulds. Such is the proceſs by which the greateſt part of the zink found in commerce, is obtained at Rammelſburg, whether in the ſtate of oxyd or metal. This zink is always united to a certain quantity of lead: it ſeems that the zink prepared in China, which comes to us under the name of *tutenag*, is much purer *, but the manner of preparing it is unknown. Sage aſſures us, that the Engliſh obtain zink in the large way, from lapis calaminaris, by diſtillation, but that their apparatus is kept a ſecret.

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* Mr. Kirwan gives the name of *tutenag* to a variety of the brittle calamine of China, which was analyſed by Mr. Engeſtrom, for which ſee the Memoirs of the Academy of Stockholm, for the year 1775. This ore is very rich, and contains from $\frac{60}{100}$ to $\frac{90}{100}$ zink.

Zink expoſed to heat in cloſe veſſels, melts before ignition, and is volatilized without decompoſition. If it be ſuffered to cool ſlowly in a veſſel, by which the melted portion of the ſemi-metal can be ſuffered to run out, the remainder of the zink is found cryſtallized in needles, or ſlender priſms. Mongez, for this purpoſe, uſes a veſſel pierced at the bottom and at its ſides, with a number of holes which he ſtops with earth of bones. When the zink cools at its ſurface, the holes are to be opened gradually, and the metal agitated by a red hot iron, introduced through one of theſe openings. This ſimple proceſs occaſions the melted portion of the zink to run out; the veſſel is then to be ſhook, till no more melted metal runs out, and the cold portion cryſtallizes. If it be left in the veſſel, it retains its metallic colour, but if it be expoſed to air, it takes a tarniſh of rainbow colours. When zink is melted with contact of air, it becomes covered with a grey pellicle, which is quickly converted into a yellowiſh oxyd, and eaſily reducible. This oxyd weighs more than the zink made uſe of, but if the metal be ſtrongly heated, it burns with a white, or light greeniſh yellow flame, very brilliant, and ſimilar to that of phoſphorus. The current of this flame drives up the oxyd of zink, which is condenſed in the air in the form of white, and very light flocks, named *flowers of zink*, *pompholix*, *nihil album*, *philoſophical wool*, *or cotton*. It is an oxyd of zink, ſaturated with oxygen, and weighs more than the metal made uſe of to form it; Baumé having obtained from each pound of zink ſixteen ounces, ſix drachms, fifty-four grains of flowers, though a conſiderable quantity muſt undoubtedly have eſcaped. It is not volatile, its ſublimation being produced only by the rapidity with which the zink burns; it conſequently remains very fixed when expoſed to heat alone in a crucible. It preſerves for a certain time a phoſphoric light, ſenſible in the dark. It may be fuſed into glaſs, by a moſt violent heat; the vitrified oxyd of zink has a beautiful yellow colour.

The oxyd and the glaſs of zink are nothing more than the metal combined with the baſe of vital air or oxygen. The glaſs does not appear to differ from the white oxyd, but by the more intimate union of the two principles. This compound is among the number of metallic oxyds which heat cannot deſtroy, and are not reducible without addition. Its decompoſition cannot be effected, unleſs it be heated in contact with combuſtible bodies. A mixture of white oxyd of zink and charcoal, or any other combuſtible body, being ſtrongly heated, zink is obtained, and the charcoal is found to be partly burned, by virtue of the oxygen it has taken from the metallic oxyd. Zink has therefore leſs affinity with the oxygen than charcoal has, though it ſeems to be more combuſtible. This operation does not ſucceed well, but in cloſe veſſels, and for that reaſon the Engliſh are ſaid to reduce lapis calaminaris by diſtillation.

Zink is ſcarcely alterable by the air. Its ſurface tarniſhes a little, and appears to ſuffer a ſlight beginning of oxydation.

Water has a ſtrong action on zink; when this metal begins to be red hot, it is then eaſily oxydated, and a large quantity of inflammable gas is given out; a proof that the water is decompoſed by the zink, which ſeizes its oxygen by the aſſiſtance of an elevated temperature. Lavoiſier and Meuſnier have aſcertained this fact in their experiments concerning the decompoſition of water. The hydrogen gas obtained in this proceſs, holds a ſmall quantity of charcoal in ſolution, which comes from the zink.

Zink has no action on the ſiliceous and aluminous earths, but its oxyd enters into vitreous compounds, and colours them yellow.

Barytes, magneſia, and lime, have no action on zink.

Cauſtic potaſh, and ſoda, being boiled on this metal, turn its ſurface black, and themſelves acquire a dirty yellow colour, by holding in ſolution a certain quantity of the oxyd of zink. This may be ſeparated by acids, as has been ſhown. Ammoniac acts leſs ſtrongly on zink when heated, no doubt on account of its volatility; but by cold digeſtion it diſſolves a ſmall quantity. In theſe three ſolutions, a certain quantity of hydrogen gas is diſengaged, the production of which appears to be due to the water. So that it is this fluid which acts on the metal, oxydates it, and renders it partially ſoluble in alkalis.

The ſulphuric acid diluted with water diſſolves zink in the cold. In proportion as the acid exerts its action, the metal becomes of a blackiſh grey, much heat is produced, and a black powder is precipitated, which was long unknown, but is found to conſiſt of carbure of iron or *plumbago*. A large quantity of hydrogen gas, holding a ſmall quantity of charcoal in ſolution, is diſengaged. This elaſtic fluid, whoſe ſmell is ſimilar to that of the gas obtained during the ſolution of iron by the ſame acid, is certainly produced by the water; for concentrated ſulphuric acid does not diſſolve zink without the aſſiſtance of heat, and then produces only ſulphureous gas. The water therefore begins the oxydation of the zink, and the acid afterwards diſſolves the oxyd of this metal. When no more hydrogen gas is diſengaged, the effervescence ceaſes, the ſmell changes, and perfectly reſembles greaſe beginning to be rancid. The liquor is whitiſh, and rather cloudy, but becomes tranſparent when diluted with water. It affords a white ſulphat of zink by evaporation, rather more ſoluble in hot than in cold water, and of which a portion cryſtallizes by cooling. Very regular cryſtals of this ſalt, known in the arts by the name of *white copperas, white vitriol, Goſlar vitriol*, are eaſily obtained by expoſing for ſome days to the air a ſolution of the ſalt made in boiling water, and a little evaporated: tetrahedral priſms are then formed, terminated by pyramids of four ſides; the ſides of theſe priſms are ſmooth. This form was pointed out by Sage and Romé de Liſle, and I have myſelf remarked it. Bucquet has obſerved that theſe priſms were rhomboidal. Monnet, however, affirms, that this ſalt cryſtallizes with great difficulty, and requires much evaporation, and ſudden cooling, to afford regular cryſtals without conſiſtence. The white oxyd of zink likewiſe diſſolves in the ſulphuric acid, and affords ſulphat of zink.

This ſalt has a ſtrong ſtyptic taſte. According to Hellot, it loſes a part of its acid by the action of fire. This acid has the characters of ſulphureous acid, and becomes hot with concentrated ſulphuric acid, according to the obſervations of Macquer. After the action of the heat, this ſulphat appears to be converted into ſulphit of zink, whoſe properties are not well known. The ſulphat of zink is very little altered by expoſure to air, when it is very pure: in the courſe of time its oxyd becomes calcined ſtill more by abſorbing oxygen; it aſſumes a yellow colour, and is no longer perfectly ſoluble in water. Sulphat of zink is decompoſable by alumine, barytes, magneſia, lime, and the three alkalis. The oxyd of zink precipitated by theſe ſubſtances may be re-diſſolved in acids, and even in alkalis. Ammoniac becomes of a dirty brown colour, after diſſolving it. The ſulphat of zink decompoſes nitre, and is itſelf decompoſed by this neutral ſalt. By diſtilling this mixture, two kinds of nitrous acid, which do not mix, are obtained, together with the glacial ſulphuric acid; we ſhall ſpeak more fully on this ſubject at the article of ſulphat of iron, or *martial vitriol.*

A ſulphat of zink, prepared in the large way at Goſlar, is met with in commerce under the name of *white vitriol.* It is made thus: blendes are roaſted, a portion of the ſulphur burns, and furniſhes ſulphuric acid, which diſſolves the oxyd of zink. The roaſted ore is then waſhed, and the lixivium being decanted, is expoſed to evaporation, and affords cryſtals. The ſalt being melted by a gentle heat, ſo as to deprive it of its water of cryſtallization, and then ſuffered to cool, becomes condenſed into white, opake, and granulated maſſes, reſembling ſugar. The *vitriol of Goſlar*, when diſſolved in boiling water, cryſtallizes by cooling. Its cryſtals are ſomewhat reddiſh, a circumſtance to be attributed to the impurities of the ſalt, which is ſuppoſed to contain a ſmall quantity of lead and iron. To purify it, zink may be thrown into its ſolution. This metal precipitates the oxyds of iron and of lead, becauſe it has a ſtronger affinity with the ſulphuric acid; and the liquor being filtrated, is conſequently found to contain pure ſulphat of zink. There is ſtill greater reaſon to think, that the impurity of the *vitriol of Goſlar* conſiſts in the oxyd of iron, from the circumſtance of the zink met with in trade being magnetical, doubtleſs becauſe it contains iron. Experiments concerning this metal ought therefore not to be made, but with zink prepared by reducing the precipitate of ſulphat of zink purified in the manner here ſhown. We muſt, however, obſerve, that zink is very often magnetical only at that part of the piece which has been cut with ſciſſars, or iron wedges.

The diluted nitric acid combines very rapidly with zink without the aſſiſtance of external heat. A conſiderable heat is produced in this ſolution, as well as in that wherein the ſulphuric acid is uſed. The lively effervefcence which accompanies this combination is occaſioned by the diſengagement of a large quantity of nitrous gas, which ſuddenly grows red by mixing with the air, when the operation has been performed in an open veſſel, but which is colourleſs, and may be confined over water, by plunging the extremity of the veſſel containing the mixture underneath the orifice of a glaſs containing that fluid. This experiment ſhows that zink decompoſes the nitric acid, and deprives it of a portion of its oxygen. If the zink be mixed with a portion of iron, it is covered with a reddiſh ochreous powder, which is merely a portion of that metal highly oxydated by the acid. If it be pure, certain flocks of a blackiſh matter, or carbure of iron, are precipitated, as is obſerved with the ſulphuric acid. The nitric acid holds a much larger quantity of oxyd of zink in ſolution than the ſulphuric. Baumé affirms, that ſix ounces of this acid diſſolved five drachms and a half of zink in leſs than two hours. The nitric ſolution of zink is of a greeniſh yellow, and not perfectly clear when newly made, but it loſes this colour, and becomes tranſparent, after ſtanding for ſome time. It is very cauſtic, and quickly corrodes the ſkin, though made with an acid diluted with water. I have obtained, by evaporation and cooling, cryſtals in tetrahedral ſtriated flat priſms, terminated by pyramids of four ſides, likewiſe ſtriated. The nitrat of zink being put on hot coals, firſt melts and detonates as the portions become dry, and the detonation is attended with a ſmall reddiſh flame. The ſame phenomenon does not appear when the fuſion is performed in a crucible. It cannot be dried, even by the mildeſt heat, without alteration; vapours of nitrous gas in this caſe eſcape, and it becomes of a brown red, and of the conſiſtence of a jelly. If it be ſuffered to cool in this ſtate, it preſerves its ſoftneſs for ſome time; but if it be kept heated for a ſufficient time, it dries entirely, and leaves a yellowiſh oxyd. Hellot has obtained from the diſtillation of nitrat of zink a very fuming nitrous acid, and obſerved the red colour it aſſumes in melting. It may be conceived, that heat diſengaging the nitrous gas of this ſalt, it paſſes to the ſtate of *nitrit of zink.* It likewiſe affords a certain quantity of oxygenous gas or vital air. The nitrat of zink quickly attracts humidity, and loſes its regular form after ſome days expoſure to the air, nothing remaining but ſtriated and pointed priſms, whoſe figure can ſcarcely be determined. It is not known whether it is decompoſable by other acids. Pott and Monnet affirm, that oxyd of zink has a ſtrong affinity with all theſe ſalts, without having any preference for any one in particular. The white oxyd of zink forms abſolutely the ſame ſalt with the nitric acid, according to Hellot. If fuming nitrous acid be uſed in this ſolution, the produce is nitrit of zink, whoſe properties are not yet exactly known.

The muriatic acid acts on zink as ſtrongly as the nitric. During the rapid effervеſcence which accompanies this combination, much hydrogen gas is diſengaged, which has the ſame properties as that afforded by the ſulphuric acid; and this laſt is known to be derived from water decompoſed by zink. Black flocks are gradually depoſited, which is nothing elſe but a combination of carbone, or charcoal and iron, or carbure of iron. The ſolution of zink by the muriatic acid is colourleſs, and does not afford cryſtals by evaporation; when heated, it becomes of a blackiſh brown, emits acrid and penetrating vapours of muriatic acid, and becomes very thick. Expoſed to the air for eight days in this ſtate, it affords no cryſtals. By diſtillation it gives out a ſmall quantity of very fuming acid, and a ſolid and fuſible muriat of zink. Hellot and Monnet have deſcribed this experiment very accurately; I have repeated it many times in my courſes of lectures, and obtained a ſmall quantity of yellowiſh acid, which was ſucceeded by a congealed matter in the neck of the retort. This muriat of zink was of the fineſt milk-white colour, very ſolid, and formed of ſmall radiated needles, in the manner of a ſtalactite. It is fuſible by a gentle heat. I have preſerved it for ſeveral years in well-cloſed veſſels of glaſs. It has attracted very little moiſture; the part which touches the glaſs is yellowiſh, and the bottom of the bottle preſents rainbow colours. This alteration doubtleſs depends on the action of light. There remains in the retort which is uſed for this diſtillation a blackiſh vitriform and deliqueſcent matter. The muriat of zink which Hellot obtained was yellowiſh; he ſays, that the ſulphuric acid diſengages the muriatic. The oxyd of zink has the ſame habitude with this acid. The oxygenated muriat of zink is not yet known.

The liquid carbonic acid in which zink or its oxyd are digeſted in the cold, diſſolves, at the end of twenty-four hours, a conſiderable quantity of this metal, according to Bergman. This ſolution, when expoſed to the air, becomes covered with a pellicle, which reflects various colours, and is merely a carbonat of zink, according to that celebrated chemiſt.

The action of the fluoric and boracic acids on zink are not known*.

All the ſolutions of zink in acids are precipitated by lime-water, magneſia, the fixed alkalis, and ammoniac. The oxyd of this metal then appears in the form of white or yellowiſh flocks, according to the ſtate of their ſolution, or the purity of the precipitant. This oxyd is reducible by the addition of combuſtible matters, is ſoluble in acids and in alkalis. When more of the latter is added than is neceſſary to diſengage the oxyd of zink, the precipitate diſappears by degrees, and the liquor aſſumes a dirty yellow colour, which indicates the ſolution of the oxyd of zink in the alkali. When, inſtead of pure and cauſtic alkalis, the carbonats of potaſh, of ſoda, and of ammoniac, are uſed to ſeparate the zink from the acids, the effervеſcence is very inconſiderable, the precipitate is white, and it is found that the carbonic acid unites with the oxyd of zink, ſo that in theſe caſes two decompoſitions and two new combinations are effected.

Zink has the property of decompoſing ſeveral neutral ſalts. If it be treated in the dry way with ſulphat of potaſh in a crucible, it decompoſes the ſalt, and forms ſulphure of potaſh in the ſame manner as antimony does. In this experiment the zink ſeizes the oxygen of the ſulphuric acid, and the acid paſſes into the ſtate of ſulphur, which the alkali diſſolves. The ſulphure formed by this combination diſſolves a portion of the oxyd of zink. All the ſulphats are likewiſe decompoſed by zink.

This metal, in filings, or in powder, cauſes nitre to detonate with ſingular rapidity. The mixture being very dry, and thrown by ſpoonfuls into a red-hot crucible, produces a white and red flame. The activity of the inflammation is ſuch, that portions of burning matter are thrown to a diſtance out of the crucible, in ſuch a manner as to require ſome precaution on the part of the operator. The zink burns by the aſſiſtance of the oxygen afforded by the nitre, and is afterwards found in the ſtate of an oxyd, more or leſs perfect, according to the quantity of nitre uſed. One part of the reſidue is ſoluble in water. It conſiſts of the potaſh combined with a portion of the oxyd of zink, which may be precipitated from its ſolution by the addition of acids. Reſpour attributed to this ſolution the property of diſſolving all the metals, if Hellot may be credited, who gives it as the *alkaheſt* of that alchemiſt.

Zink, according to the experiments of Pott, appears capable of decompoſing muriat of ſoda. It eſpecially decompoſes ammoniacal muriat with great facility. Monnet affirms, that this metal triturated with ammoniacal muriat, diſengages the ammoniac. Bucquet has obſerved, that when this ſalt and zink are diſtilled together, much ammoniac gas and hydrogen gas are produced by the combination of the muriatic acid with this metal: and he was ſenſible that the facility with which the zink diſengages the ammoniac, is a conſequence of its ſtrong action on the muriatic acid. The oxyd of zink likewiſe diſengages it, according to Hellot. The reſidue of this decompoſition is muriat of zink, which may be ſublimed.

When a ſolution of ſulphat of alumine is boiled with filings of zink, a decompoſition takes place, which affords the ſulphat of this metal. The baſe of this ſalt, therefore, ſeems to have a weaker affinity than zink with the ſulphuric acid. This fact was obſerved by Pott, and we ſhall have occaſion to make the ſame remark with regard to many other metallic ſubſtances.

The effects of hydrogen gas on zink have not yet been examined. I have only obſerved, that this metal, plunged in this gas, aſſumes, after a certain length of time, a beautiful blue and changeable colour; but I have not followed this alteration any further. It does not ſeem capable of reducing the oxyd of this metal, which retains the oxygen with great force, and which decompoſes the water.

Zink does not appear to combine with ſulphur but with the greateſt difficulty. When theſe two ſubſtances are melted together, they remain diſtinct without contracting any kind of union. Dehne, however, obſerved, that if they be kept for a certain time in fuſion together, the zink is partly oxydated, aſſuming at the ſame time a brown or greyiſh colour, and becoming heavier. Morveau diſcovered, ſince the time of the remark of Dehne, that the oxyd of zink unites eaſily with ſulphur by fuſion, and that a grey mineral is produced very ſimilar to the *blende* of Huelgoet, from which yellow and priſmatic needles are ſometimes ſublimed, and fix themſelves to the cover of the crucible. Morveau obſerves, that it is ſtill more probable that *blende* is naturally formed by the combination of the oxyd of zink and ſulphur, as native zink has never yet been found.

Malouin has not ſucceeded in his attempts to combine zink with the alkaline ſulphure, whether by the humid or by the dry way, or by varying the proportions of theſe two ſubſtances to each other[b].

The ſame chemiſt combined zink with arſenic. He obſerved, that this metal does not unite ſo well with zink, as the oxyd of arſenic does ; nevertheleſs, in an experiment, wherein he diſtilled a mixture of this oxyd with tallow and zink, he obtained a blackiſh maſs reſembling blende, but leſs conſiſtent. It likewiſe appears that the zink ſeizes the oxygen of the oxyd of arſenic when they are diſtilled together, and that a portion of this metal is burned, at the ſame time that a portion of the oxyd of arſenic is revived. A ſeries of experiments, made with a view to diſcover the reciprocal action of metallic oxyds and metals on each other, and to determine the elective attractions of the oxygen with theſe ſubſtances, could not fail of proving highly inſtructive.

It is not known whether zink is capable of being alloyed with cobalt.

It does not combine with biſmuth, and when theſe two metals are fuſed together, the biſmuth takes the lower place on account of its greater weight, and they may be ſeparated by a ſtroke of the hammer.

Zink, fuſed with antimony, affords a hard and brittle alloy, which Malouin ſimply mentions, without pointing out any of its other properties.

Zink is of great uſe in the arts. It is employed in many alloys, eſpecially in tombac, ruchbec, or prince's metal Fine filings of zink are uſed to produce the white and brilliant ſtars in fire-works. Some perſons have propoſed to ſubſtitute this metal inſtead of tin for lining veſſels, the tin having been ſuppoſed to be dangerous. Malouin, after having compared theſe metallic ſubſtances in Two Memoirs, printed among thoſe of the Royal Academy of Sciences for the years 1743 and 1744, gives an account of the experiments made by him reſpecting the lining of veſſels with zink. From his reſearches it appears, that this lining ſpreads more evenly on the copper, is much harder, and leſs fuſible than that of tin, and conſequently more durable, and leſs ſubject to leave the copper uncovered. Macquer, who acknowledges theſe advantages, has however made ſeveral very important obſervations concerning the uſe of zink for culinary veſſels, and thinks it dangerous, becauſe it is ſoluble in vegetable acids, ſuch as vinegar, verjuice, &c. and has a conſiderable emetic power. He proves this by the ſulphat of zink, which was formerly employed as a vomit under the name of *gilla vitrioli*, and by the teſtimony of Gaubius, who mentions a celebrated remedy for convulſive diſorders, named *Luna fixata Ludemanni*, or the ſublimed oxyd of zink. This pretended luna fixata was ſtrongly emetic in very ſmall doſes. But may it not be preſumed that theſe objections, which are applicable only to the ſulphat and the oxyd of zink, cannot be applied to the metal itſelf, nor even without further experiments to the ſalts formed by its combination with vegetable acids. Planche, doctor in medicine of the faculty of Paris, has changed this preſumption into certainty, by experiments made with great care on himſelf. He took the ſalts of zink, formed by the vegetable acids, in a much ſtronger doſe than the aliments prepared in copper tinned with zink can poſſibly contain them, and no dangerous effect followed the uſe of theſe compounds. However, ſince objects which relate to the health and the lives of mankind cannot be treated with too much circumſpection, it appears to me to be prudent and even neceſſary not to decide on this ſubject till it has been well eſtabliſhed by a great number of experiments, what the action of zink and its ſalts, formed with the vegetable acids employed in cookery, is upon the animal economy.

The German phyſicians employ the ſublimed oxyd of zink with ſucceſs as an antiſpaſmodic in convulſions and epileptic fits. It is not much uſed in France, yet it appears that this remedy might be uſefully adminiſtered in pills in the doſe of half a grain each day. I have been aſſured, that a much more conſiderable doſe has been taken at Edinburgh without any ſenſible effect. This fact is contrary to what Gaubius aſſerts concerning the emetic property of this oxyd of zink. *Pompholix*, *tutty*, or the different oxyds of zink, &c. are uſed as excellent deſiccative medicines, to be externally applied in diſorders of the eyes.

NOTES ON CHAPTER XIV.

ZINK.

[a] FLUORIC acid forms a ſalt with zink, which has not yet been obtained in a ſolid form.

Boracic acid acquires a milky appearance by digeſtion on zinc; but the nature of the combination which it forms is unknown.

Phoſphoric acid attacks zink with violence. The ſolution does not cryſtallize, but it affords by evaporation a tranſparent maſs, which may be melted into glaſs by the blow-pipe. If dry phoſphoric acid be melted with zink, the acid is decompoſed, the zink is changed to the ſtate of an oxyd, and phoſphorus produced.

Tartaric acid diſſolves zink with effervеſcence, and forms with it a difficultly ſoluble tartarit of zink.

Oxalic acid diſſolves zink with effervеſcence, and forms with it a white powder, which becomes ſoluble in water only by an exceſs of acid. According to Bergman this combination contains ſeventy-five parts of metal. The oxalic has the greateſt affinity of all the acids for zink.

Acetic acid diſſolves zink and its oxyd. The acetat of zink is obtained in the form of long ſpicular cryſtals, which have a metallic taſte, and may be decompoſed in the fire.

The ſuccinic acid, in combination with zink, forms long, parallel lying, foliated cryſtals.

The citric acid diſſolves zink and its oxyd; with the former it gives out hydrogen gas.

The malic acid diſſolves zink, and forms with it a cryſtallizable ſalt.

The benzoic acid diſſolves readily the oxyd of zink, and forms with it groups of radiated cryſtals. This ſalt has a ſweetiſh aſtringent taſte, effloreſces in the air, and is ſoluble in water and ſpirit of wine.

Arſenic acid, according to Scheele, has no action on zink in the cold, but it diſſolves it with efferveſcence by the aſſiſtance of heat. The elaſtic fluid diſengaged, ſeems to be an arſeniated hydrogenous gas. The ſolution ſhoots by evaporation into cubic cryſtals. The greater part of the arſenic acid may be ſeparated from this ſalt in its metallic ſtate by expoſure to a ſtrong heat. If dry arſenic acid be melted with zink, inflammation, with a crepitating noiſe, is produced. One part of the arſenic riſes in the form of a white oxyd, and the other remains in union with the zink. Arſenic acid takes zink from the acetic.

Pruſſiat of alkali produces a white precipitate in the acid ſolutions of zink, which becomes yellow by drying.

The gallic acid precipitates the zink of a yellowiſh grey colour.

On account of the eaſy oxydation of zink, it is difficult to combine it with phoſphorus. This combination, according to Pelletier, is moſt eaſily effected, by throwing at different times ſmall pieces of phoſphorus upon zink, heated in a crucible, and by covering the mixture with reſin to prevent the oxydation of the metal. Phoſphure of zink has a metallic luſtre, not unlike that of lead; it is ſlightly malleable, burns in the fire like zink, and leaves behind it a ſpongy reſidue.

Gold and zink melt eaſily together. Equal parts of theſe metals form a hard brittle maſs, which receives an excellent poliſh. The zink may be ſeparated from the gold by oxydation in the fire, or by ſolution in nitric acid.

Zink unites eaſily with platina, and forms with it a brittle hard blueiſh coloured mixture. It is very difficult to ſeparate it entirely from the platina by roaſting. Zink precipitates platina from its ſolution in aqua regia. Four hundred and ſixteen parts of zink are required, according to Bergman, to precipitate ſeventy-ſeven parts of platina.

Silver forms a brittle maſs with zink, which, like that with gold, may be decompoſed in the fire. The ſilver is precipitated by zink from its ſolution in nitric acid, partly in an oxydated, and partly in a metallic ſtate. A portion of the zink, however, falls along with the ſilver.

Zink amalmagates eaſily with mercury. Five parts of zink and one of mercury, mixed up with a little fat, anſwer very well for an amalgam for electrical machines. Zink precipitates mercury in its metallic ſtate from its ſolution in acids, but the falling mercury is apt to amalgamate with the unchanged portion of zink. If oxygenated muriat of mercury be diſtilled with zink, a muriat of zink paſſes over into the receiver, and the mercury remains fluid in the retort.

To combine lead with zink it is neceſſary to cover the mixture with charcoal, and to exclude from it carefully the external air. Zink precipitates lead from acids. Very beautiful *metallic vegetations*, as they have been termed, may be produced by ſuſpending a bit of zink in a ſolution of acetat of lead.

It does not appear to be determined whether zink can be made to combine with biſmuth. It precipitates the biſmuth in its metallic ſtate from acids.

Zink unites with nickel. It occaſions no perceptible precipitation of nickel from acids.

Zink unites difficultly with arſenic, not taking up more than 1-5th of that metal. The mixture is of a grey colour, and brittle. If oxyd of arſenic be melted with zink, the zink is oxydated, and a portion of the arſenic riſes in its metallic ſtate. See *Gren's Handbuch. Zink.*

Chemiſts differ in opinion with regard to the poſſibility of combining zink with iron, but the difficulty ſeems to ariſe chiefly from the volatility and eaſy oxydation of the zink. Iron is precipitated by this metal from its ſolutions in acids; the precipitate approaches more or leſs to the metallic ſtate, according to the previous degree of its own oxydation, and the oxydation of the zink.

Zink melts difficultly with cobalt. It does not precipitate this metal from acids, nor change the red colour of its ſolutions. A very beautiful green paint is produced in precipitating by potaſh from a mixture of cobalt diſſolved in aqua regia, and nitrat of zink, the oxyds of theſe metals. The preſence of iron deſtroys the beauty of the colour.

Zink unites eaſily with tin, and renders it harder and more brittle. It precipitates tin from its ſolution in acids. With the muriatic and acetic ſolutions it produces metallic vegetations.

CHAPTER XV.

CONCERNING MERCURY.

Mercury, or quickſilver, has the opacity and brilliancy of metals, and next to gold and platina is the moſt ponderous ſubſtance we know: a cubic foot of pure mercury weighs 947 pounds; it loſes by immerſion in water about one thirteenth of its weight[a]. As it is continually fluid, its tenacity and ductility are not well known, and it ſtill remains a queſtion among what ſpecies of metallic bodies it ought to be placed. Like the ſemi-metals it is volatile. It has a kind of ductility, reſembling the metals; but its extreme weight, its habitual fluidity, its volatility, and the ſingular alterations it is capable of undergoing in many combinations, ſeem to juſtify the ranking it as a peculiar ſubſtance, which ſeems to belong to the metallic matters only by its brilliancy, weight, opacity, and combuſtibility.

It was long taken for granted, that mercury could not be deprived of its fluidity; but the academicians of Peterſburg have proved the contrary. Theſe learned men availed themſelves of the exceſſive cold in the year 1759, to try many important experiments. They increaſed the natural cold by the aſſiſtance of a mixture of ſnow and fuming ſpirit of nitre, and by that means ſucceeded in cauſing a mercurial thermometer to fall to 213 degrees, according to the graduation of De Liſle; which anſwers to 46 degrees below freezing of the gradation of Reaumur. Theſe philoſophers, obſerving that at this degree the mercury deſcended no longer, broke the ball of glaſs, and found the metallic fluid frozen in the form of a ſolid, which, on trial, proved capable of extenſion under the hammer. This experiment demonſtrated that mercury, like all other metallic ſubſtances, is capable of aſſuming the ſolid form, and that it is then in a certain degree ductile. They could not determine the degree of ductility it is ſuſceptible of, becauſe every ſtroke of the hammer communicating heat to ſome part of the metal, melted it, and cauſed it to flow in that point.

Pallas, who ſucceeded in congealing mercury in the year 1772, at Kraſnejark, by the natural cold of 55 degrees and an half, obſerved that it then reſembled ſoft tin, and was capable of being beat out into plates, that it broke eaſily, and that the pieces being brought together united again. In the year 1775, Mr. Hutchins obſerved the ſame phenomenon at Albany fort, and Mr. Bieker at Rotterdam in 1776, at the fifty-ſixth degree below Zero. Laſtly, This congelation was effected in the year 1783, in England, at a more moderate degree of cold; and it was determined that 32 degrees below Zero of the thermometer of Reaumur, is the term at which this congelation takes place. If therefore the mercury deſcended lower in the early experiments, the phenomenon muſt be attributed to the condenſation of the ſolid metal. Hence we ſee that this metal is the moſt fuſible of any we know. The greateſt cold known in the countries from whence it is obtained, cannot render it ſolid. It is probable that if in the preceding experiments the cold by which the mercury was frozen had been produced by inſenſible degrees, that metallic ſubſtance would have taken a regular cryſtallized form [b].

The habitual fluidity of mercury has cauſed it to be eſteemed a peculiar metallic water, and it has been called *aqua non madefaciens manus*, water which does not wet the hands. It is true that mercury does not wet the hands, nor moſt of the other bodies which may be wetted by water, oils, and other liquids; but this phenomenon depends only on the ſmall degree of affinity which exiſts between that metallic fluid and the bodies themſelves; for when it is in contact with ſubſtances with which it can unite, as gold, ſilver, tin, &c. it becomes cloſely united to them, and wets them in ſuch a manner, that they cannot be dried again but by evaporating the mercury which adheres to them.

Mercury being a melted metal, always affects the form of globules when it is divided; and when it is confined in a bottle its ſurface appears convex. This effect depends both on the ſmall degree of affinity which mercury has with glaſs, and the ſtrong attraction that tends to bring the parts of this metal together; for if the fluid be placed in a metallic veſſel with which it has an affinity, its ſurface then appears concave, like that of other fluids, becauſe it combines with the ſides of the veſſels.

Mercury has no taſte that the nerves of the tongue and palate can perceive, but it produces a very evident effect on the ſtomach and inteſtines, as well as on the ſurface of the ſkin. Inſects and worms are infinitely more ſenſible of this taſte than other animals, and for that reaſon it very ſoon kills them; and phyſicians adminiſter it as an excellent vermifuge. It is by virtue of this property likewiſe that it cures the itch, and other cutaneous diſorders, which many philoſophers have thought to be produced by certain inſects, which penetrate the texture of the ſkin. But this opinion has not been generally adopted, though ſeveral naturaliſts have deſcribed the animal, which cauſes the itch, &c.

Mercury rubbed for a ſhort time between the fingers emits a ſlight peculiar ſmell. When it is very pure, and is agitated, it is ſometimes obſerved, more eſpecially in hot weather, to ſhine with a ſmall phoſphoric light clearly diſcernible. This phenomenon has been ſhown with the mercury of the barometer by ſeveral natural philoſophers [*]. If the hand be plunged in this metallic fluid, a ſenſation of cold is perceived, which ſeems to ſhow that its temperature is much beneath that of the atmoſpheric air; yet by plunging a thermometer in the ſame mercury, it is immediately ſeen that their temperatures do not differ. This effect, which deceives us, is to be attributed entirely to the great rapidity with which the heat paſſes from the hand into the mercury, for this metal is known to be a powerful conductor of heat.

Mercury, when divided by continual agitation, ſuch as that of the ſails of a mill, changes by degrees into a very fine black powder, called *Ethiops per ſe*, by reaſon of its colour. As the mercury experiences a commencement of combuſtion in this experiment, this powder is called *black oxyd of mercury*. The mercury, by a ſlight heat, or by trituration in a warm mortar, may be made to reſume its uſual fluidity and brilliancy.

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[*] This phenomenon is produced by the efflux of the electric fluid into the vacuum over the mercury; that fluid being diſengaged by the friction between the non-electric mercury and the electric glaſs. T.

Mercury is not found abundantly in nature. It is met with in the earth, either in the virgin ſtate, poſſeſſing all its uſual properties, or in the ſtate of an oxyd, or combined with acids, ſulphur, or other metallic matters in the mineralized ſtate.

Running mercury is found in globules, or larger maſſes, in friable earths and ſtones, and moſt commonly exiſts in the clefts or cavities of its ores. At Idria, in Spain, and in America, it is collected in the cavities and clefts of rocks. It is likewiſe found ſometimes in clay at Almaden, and in beds of chalk in Sicily. Laſtly, It is found in ſilver and lead ores, and mixed with the white oxyd of arſenic.

Sage mentions an ore of mercury, in the ſtate of an oxyd, at Idria, in Friuli; it is of a brown red, very ſoft, and granulated in its fracture; ſome globules of running mercury exiſt in it, and it is reducible by mere heat, without addition. Kirwan conſiders it as the combination of mercurial oxyd and carbonic acid; one hundred parts of the ore afford ninety-one parts of mercury.

In the year 1776, Mr. Woulfe found at Obermuſchel, in the duchy of Deuxponts, a cryſtallized, ponderous, ſpathoſe, white, yellow, or greeniſh ore of mercury, in which, by means of alkalis, he diſcovered the preſence of the ſulphuric and muriatic acids. It is a compound of ſulphat of mercury, and corroſive mercurial muriat. Sage affirms, that it contains eighty-ſix parts of mercury in the hundred. This chemiſt has deſcribed a corneous brown ore of mercury, from Carinthia. Mercury is moſt commonly found naturally combined with ſulphur; it is then known by the name of *cinnabar*. This mineral ſubſtance is red, and has not a metallic appearance, though the quantity of ſulphur is but ſmall in compariſon to the mercury; a proof that the combination of theſe two bodies is very intimate. Cinnabar is found in the duchy of Deuxponts, in the Palatinate, in Hungary, in Friuli, and Almaden in Spain, and in South America, eſpecially at Guamanga in Peru. It is ſometimes compact, and its colour varies from a pale red, to a deep and blackiſh red. Sometimes it is found in tranſparent ruby-coloured cryſtals, and often in a kind of ſcales, or flattened laminæ. It is called *native vermilion*, and *cinnabar in flowers*, when it is in the form of a very brilliant red powder. Laſtly, It is found diſperſed with different earths in ſulphat of lime, mixed with iron, with pyrites, and with ſilver.

Mr. Cronſtedt in his Mineralogy, ſpeaks of an ore of mercury, in which that ſubſtance is united to ſulphur and copper; it is of a blackiſh grey, brittle and ponderous; its fracture is vitreous, and it decrepitates in the fire. It is found at Muſchel Lanſberg.

The ſame mineralogiſt affirms, that mercury amalgamated with virgin ſilver, has been found in the mine of Sahlberg in Sweden. Romé de Liſle has in his cabinet a piece which he thinks to be of this ſpecies.

Monnet, in his Syſtem of Mineralogy, ſpeaks of an ore brought from Dauphiny, by Mr. Montigny, in the year 1768, which contained mercury, ſulphur, arſenic, cobalt, iron, and ſilver. It is grey, whitiſh, and friable. He found it to contain one pound of mercury, and three or four ounces of ſilver per quintal.

After this ſhort account of the properties of the metal, the different ſtates in which mercury is found in the earth, may be reduced to the following varieties:

STATE I.

Native Mercury.

Diſſeminated in earths and ſtones, and moſt commonly in its own ores.

STATE II.

Native Oxyd of Mercury.

STATE III.

Native Sulphat and Muriat of Mercury.

STATE IV.

Mercury mineralized by Sulphur; Cinnabar.

Varieties.

1. Tranſparent cinnabar, red and cryſtallized in very ſhort triangular priſms, terminated by triangular pyramids.
2. Tranſparent red cinnabar, in octahedral cryſtals, conſiſting of two triangular pyramids, united at their baſes, and truncated.
3. Solid compact cinnabar, of a brown or bright red; it is ſometimes foliated.
4. Red cinnabar diſtributed in ſtriæ, on a ſtony matrix, or on ſolid cinnabar; it is ſometimes compoſed of needles like cobalt.
5. Cinnabar in flowers; native vermillion. It is a cinnabar of a brilliant red, of a ſatin appearance, which adheres to different matrices, under the form of a very fine powder; it is ſometimes cryſtallized in very ſmall needles, and then greatly reſembles the foregoing variety.

STATE V.

Mercury combined with Sulphur and Copper; black and vitreous Ore of Mercury of Cronſtedt.

STATE VI.

Mercury united to Sulphur, Arſenic, Cobalt, Iron, and Silver.

STATE VII.

Mercury united to Silver, Native Amalgama of Silver.

An ore of mercury is known by pounding and mixing it with lime or alkalis; this being thrown on a hot brick, and the whole covered with a veſſel in the form of a bell, the mercury is reduced into vapours, and condenſes on the ſides of the veſſel. If the object be to diſcover the quantity of mercury it contains, the ore, after being pulverized and waſhed, muſt be diſtilled with ſuch additional matters as are capable of ſeizing the ſulphur, and diſengaging the mercury. Water is placed in the receiver, for the purpoſe of condenſing and collecting the mercury. If the ore be carefully weighed before the aſſay, and likewiſe the mercury obtained by diſtillation, the proportional quantity, which may be expected from any other maſs of the ore, will be known.

Virgin mercury is eaſily ſeparated by pulverizing the ſtones in which it is mixed and waſhing them in water. The metal precipitates, and the earth is carried off by the water. The ores of Idria, in Friuli, are treated in this manner.

Cinnabar is too volatile to admit of its ſulphur being diſſipated by roaſting; but being almoſt always found mixed with a calcareous or martial ſubſtance, it may in general be decompoſed by fire, without any other medium.

Antoine De Juſſieu, in the Memoirs of the Royal Academy for the year 1779, has deſcribed the proceſs made uſe of at Almaden, in Spain, to obtain mercury from cinnabar. The ore containing iron, and a ſmall quantity of calcareous ſtone, is put into furnaces, which are formed like reverberatory furnaces, and are heated by a fire made on a grate below. The furnace has no opening, except eight holes at its back part. At each of theſe a row of aludels is adapted, the laſt of which reſts on a ſmall ſtructure, at a conſiderable diſtance from the furnace. Between the furnace and the ſtructure, at which the aludels terminate, is a ſmall terrace or ſloping bank, the higher part of which is even with the apertures of the furnace, and the lower with that of the ſupport of the laſt aludel. It is conſequently an inclined plane, and ſerves to ſupport the intermediate veſſels. If any mercury eſcapes for want of a proper cloſure, it is collected at the junction of the inclined planes of the terrace. When the fire is applied to the cinnabar, the iron and calcareous ſtone unite with the ſulphur; and the mercury being reduced into vapours, paſſes into the aludels. After the diſtillation, all the aludels are carried into a ſquare chamber, whoſe floor ſlopes towards a cavity in the middle, into which mercury is emptied.

De Juſſieu obſerves, that the ores of cinnabar do not emit any exhalation noxious to vegetables, and that the environs of the mines of Almida, as well as the ground above them, are very fertile. He likewiſe remarked, that the working of this mine is not pernicious to the workmen, as has been ſuppoſed; and that thoſe who work in the interior part of the mine, as felons, are the only perſons who are ſubject to any danger, becauſe the fires, which they are obliged to make, volatilize a portion of the mercury, to the vapours of which they are continually expoſed.

Sage, in the Memoirs of the Academy for the year 1776, has deſcribed the proceſs employed to extract mercury from cinnabar, in the Palatinate. The furnace has a gallery charged with forty-eight retorts of caſt iron, one inch thick, and three feet nine inches long, containing about ſixty pounds of the matter to be diſtilled. Theſe retorts are immoveably fixed in the furnace. A mixture of three parts of the ore well pounded, with one part of ſlaked lime, is introduced by iron ladles. The heat is produced by pit-coal put in at the two extremities of the furnace, the ſides being pierced in ſeveral places to give ſufficient air to maintain the combuſtion. The mercury riſes by means of the re-action of the lime on the ſulphur, and is collected in receivers of earth, adapted to the retorts, and one third filled with water. This operation laſts ten or eleven hours.

Mercury obtained, or revivified, from cinnabar, is very pure, and contains no foreign matter. The mercury met with in commerce is ſeldom of this degree of purity, as it is almoſt always mixed with foreign metallic matters, whence it appears tarniſhed, and inſtead of dividing itſelf into neat globules, it flattens, and ſeems to be covered with points. The merchants then ſay it *draws a tail.*

Mercury does not appear to be altered by the action of light. It is very quickly, and regularly heated; that is to ſay, its dilatation is extremely regular, as Bucquet and Lavoiſier have ſhown, by their experiments into the effects of heat on different fluids, read at the Academy of Sciences. This phenomenon proves, that mercury is the fitteſt fluid to aſcertain exactly the degrees of heat, and forms the beſt thermometers *.

This metallic fluid, expoſed to heat in cloſed veſſels, boils in the ſame manner as liquids [c], a property not peculiar to mercury, but common to ſilver, gold, and moſt other metals. It is true, that as mercury is more fuſible than any other metal, it boils ſooner, and long before the red heat. Ebullition is nothing but the tranſition from the liquid to the vaporous ſtate. The vapour of mercury, which is diſtinctly viſible, in the form of a white fume, and, for the time, deprives the veſſels in which it is received of their tranſparency, is condenſed by cold into drops of mercury, which are equal to the quantity put into the retort, and have ſuffered no alteration, provided the mercury be extremely pure, and the diſtillation carefully conducted. Mercury is therefore a very volatile ſubſtance, which may be diſtilled like water, and in this property it approaches to the nature of ſemi-metals, or brittle metals.

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* De Luc aſcertained this point in his *Recherches ſur les Modifications de l'Atmoſphere.* T.

Boerhaave diſtilled the ſame quantity of mercury five hundred times ſucceſſively, and found it not in any reſpect altered. It only appeared rather more brilliant, heavy, and fluid; doubtleſs becauſe the purification was very accurate. In this diſtillation he obtained a ſmall quantity of grey powder, which appeared to him to conſiſt of mercury in a ſtate of extreme diviſion, and became fluid and brilliant by ſimple trituration in a mortar. It was a little black oxyd of mercury produced by the air contained in the apparatus.

Diſtillation is the beſt method of purifying mercury, and of ſeparating the mixed metals, with which it is uſually vitiated in commerce. The foreign metal is found in the retort, in a brilliant cruſt in ſome parts, and blackiſh in others. By weighing this reſidue, the quantity of matter, with which the mercury was vitiated, is known.

The extreme weight of mercury cauſed chemiſts to imagine that it contains the pure terreſtrial principle, or vitrifiable earth, in great abundance; but this principle, when it abounds in bodies, gives them ſolidity, and mercury is, on the contrary, very fuſible; and again the earthy principle is fixed, and mercury is exceedingly volatile. Theſe circumſtances appearing contradictory, engaged Beccher to admit in this metallic fluid a peculiar earth, which he denominated, as we have before obſerved, *mercurial* earth, and attributed to it exceſſive weight, together with volatility. Mercury was therefore, according to this chemiſt, a compound of three earths, viz. the vitrifiable, the inflammable, and the mercurial. The exiſtence of the latter having never yet been proved, this opinion muſt therefore be conſidered as a mere unſupported aſſertion. Mercury appears like all metallic ſubſtances, to be a peculiar combuſtible body, whoſe firſt principles have not yet been ſeparated. As to the vitrifiable earth, whoſe properties we have examined at the commencement of this work, we do not think that there is reaſon to admit it in mercury, more than in other metals since no ſuch principle has been extracted from it. The ſubſtance diſtinguiſhed by that name by Beccher and Stahl, and ſuppoſed to exiſt in mercury, and in other metallic ſubſtances, is far from being a ſimple and earthy ſubſtance, as we have already obſerved in ſpeaking of metallic oxyds in general.

Mercury, reduced into vapour, has a very conſiderable force of expanſion, and is capable of producing dangerous exploſions, when confined. Hellot related to the Academy, that a certain perſon, being deſirous of fixing mercury, had put a quantity into an iron ball, well ſoldered together. The ball being thrown into the middle of a heated furnace, had ſcarcely become red, when the mercury burſt through its confinement with a conſiderable noiſe, and eſcaped. Baumé, in his *Experimental Chemiſtry*, relates a ſimilar fact, of which Geoffrey, the apothecary, was witneſs.

Mercury is infinitely more ſuſceptible of oxydation by the contact of air, and many other bodies, than has hitherto been ſuppoſed. A grey blackiſh pellicle is continually formed upon its ſurface, which is a true oxyd of mercury.

Heated with the concourſe of air, this metal, at the end of ſome days, becomes changed into a brilliant red powder, of an earthy appearance, diſpoſed in ſmall ſcales. This powder, which no longer poſſeſſes the metallic aſpect, is a true mercurial oxyd. The alchemiſts, who believed that the mercury was fixed in this experiment, called it, improperly, mercury precipitated by itſelf, or *precipitate per ſe.* As mercury, though very volatile, requires nevertheleſs the concourſe of air to calcine it, an inſtrument ſufficiently commodious has been invented for this operation, uſually called *Boyle's Hell.* It is a large glaſs veſſel, flat at the bottom, ſo that the mercury, encloſed within it, forms a very thin ſtratum, and conſequently preſents a large ſurface. It is cloſed by a ſtopper, accurately fitted to its neck, and perforated by an exceedingly ſmall hole. The veſſel is placed on a ſand bath, and the mercury heated till it boils. The opening in the ſtopper, on account of its minuteneſs, ſuffers the air to have acceſs to the bottle, without ſuffering the mercury to eſcape. At the end of ſeveral months of digeſtion, an oxyd, which is formed on the ſurface of the mercury, may be ſeparated. This is done by pouring the whole into a piece of cloſe linen; the mercury paſſes through by preſſure, and the red oxyd remains on the cloth. This proceſs may be performed with equal ſucceſs, with a flat bottomed matraſs, into which a ſufficient quantity of mercury is poured to form a thin ſtratum. The neck of the matraſs is afterwards drawn out into a capillary tube, and the point broken off. This method, contrived by Baumé, is better adapted to the oxydation of mercury, becauſe the veſſel contains more air. It is likewiſe more eaſily heated, leſs expenſive, and leſs ſubject to be broken than Boyle's veſſel. To ſucceed in this experiment, the mercury muſt be kept in a heat ſufficient to make it boil gently night and day for ſeveral months. By placing a number of ſuch veſſels on the ſame ſand bath, a very large quantity of *precipitate per ſe*, or red oxyd of mercury, may be obtained, and a certain quantity may be had in fifteen or twenty days[d].

The *precipitate per ſe* is a true oxyd of mercury, or combination of that metallic ſubſtance, with oxygen, which it gradually ſeizes from the atmoſphere. This is proved in a convincing manner, from the following circumſtances: Firſt, Mercury can never be converted into *precipitate per ſe*, without contact of air. Secondly, This combination cannot be made but with vital air, and does not take place in the different gaſes which are not pure air. Thirdly, The mercury in this experiment becomes heavier.[e]. Fourthly, When heated in cloſed veſſels, it may be entirely reduced into running mercury, at the ſame time that a large quantity of elaſtic fluid is diſengaged, in which combuſtible bodies burn four times more rapidly than in the air of the atmoſphere. This is the ſame fluid that was firſt diſcovered by Dr. Prieſtley, and by him called *dephlogiſticated* air, and which we call *oxygen gas*, or vital air. The mercury loſes by reduction the weight it had acquired during calcination.

This laſt fact, together with the phenomena of the combuſtion of mercury, as far as relates to the neceſſity of the free admiſſion of air, and its diminution in the operation, has induced Lavoiſier to conclude, from analogy as well founded as any admitted in natural philoſophy, that metallic oxyds are mere combinations of metals with the oxygen of the air. As the *precipitate per ſe* may be very well analyſed by heat; and as it ſeparates into two principles, pure vital air, and running mercury, it is evident how ſtrongly this valuable experiment tends to explain, and to prove the pneumatic theory. It is eaſily underſtood, that the baſe of vital air, or the oxygen which was fixed in the mercury, becomes diſengaged by recovering its elaſticity with the aſſiſtance of heat. To reduce the red oxyd of mercury in this manner, it muſt be heated in veſſels accurately cloſed. If the air has acceſs to it, it remains in the ſtate of oxyd, becauſe it always finds in the atmoſphere the body with which it unites, and which alone has the property of oxydating it. From this circumſtance it was that Baumé inſiſted, that *precipitate per ſe* is not reducible, but, on the contrary, ſublimes in reddiſh cryſtals of a ruby colour; while Cadet has maintained, that all *precipitates per ſe* are equally reducible into fluid mercury. Macquer has ſhown, by an ingenious explanation, which perfectly agrees with the facts, that both theſe chemiſts were in the right; and that if the oxyd of mercury be heated with acceſs of air, it ſublimes totally, and may even be melted into a moſt beautiful red glaſs, as Mr. Keir, a learned Scotch chemiſt, has aſſerted, in his tranſlation of the Dictionary of Chemiſtry; but that the ſame oxyd, though capable of ſubliming with the contact of air, is reduced into a running mercury, and gives out vital air, when it is ſtrongly heated in well-cloſed veſſels.

Mercury is not altered by expoſure to air. It is only obſerved, that it becomes tarniſhed by the particles of duſt, which the air depoſits, and from that circumſtance mercury has been called the *loadſtone of duſt*. All bodies, however, ſeem to have this property, though it is moſt ſenſible in this metal, on account of its brilliant ſurface. But it is not at all changed by this circumſtance; nothing more being neceſſary to give it its original brilliancy, than filtration through a piece of ſhammoy leather.

Mercury does not ſeem to diſſolve in water. Phyſicians are, nevertheleſs, in the habit of cauſing a bag full of this metal to be ſuſpended in vermifuge decoctions during their ebullition; and experience has ſhown, that this practice is attended with good effects. Lemery affirms, that mercury loſes nothing of its weight by this decoction. It is probable, that a principle, ſimilar to that of ſmell, emanates from the mercury, a principle ſo fugitive and ſubtle, that its weight cannot be found. It is perhaps this principle that communicates the anthelminthic virtue to water.

Mercury does not unite to earths more than other metallic ſubſtances; its red oxyd, or *precipitate per ſe*, might perhaps fix in glaſſes, and colour them, as is obſerved to happen with the oxyd of arſenic.

The action of barytes, magneſia, lime and alkalis on mercury, are not known.

The ſulphuric acid does not act on this metallic ſubſtance but when it is well concentrated. To make this ſolution, one part of mercury is poured into a glaſs retort, and one part and a half, or two parts of concentrated ſulphuric acid, are added; the mixture is heated, and a violent efferveſcence is ſoon after excited; the ſurface of the mercury becomes white, and a powder of the ſame colour is ſeparated, which renders the acid opake; and a large quantity of ſulphureous gas is diſengaged, which may be collected over mercury. This method, as we have ſeen in ſpeaking of the ſulphuric acid, is moſt commonly uſed to obtain that gas. A portion of water charged with ſulphureous acid gas likewiſe paſſes over. When this diſtillation is urged till the ſulphureous acid no longer paſſes over, a white opake very cauſtic maſs is formed at the bottom of the retort, which weighs one third more than the mercury made uſe of, and ſtrongly attracts the humidity of the air. The greateſt part of this maſs is an oxyd of mercury united to a ſmall portion of the ſulphuric acid. It is conſiderably fixed, according to the obſervations of Kunckel, Macquer, and Bucquet. In this operation the ſulphuric acid is decompoſed by a double elective attraction; the mercury, which is a combuſtible ſubſtance, unites to the oxygen contained in the acid, while the heat diſengages the ſulphureous gas and the water. The metal muſt therefore be in the ſtate of an oxyd, and muſt conſequently have much more fixity than fluid mercury.

A portion of this ſulphuric mercurial maſs is ſoluble in water. When a large quantity of water is poured upon it, it mixes with the maſs, and a white powder precipitates, if the water be cold; but if boiling water be uſed, the powder is of a beautiful brilliant yellow colour, which is ſo much the more lively, as the quantity of water and the heat are greater. This was anciently called *turbith mineral*, or *yellow precipitate.* We now call it yellow mercurial oxyd. The water which ſerved to waſh it is decanted, and a new quantity of boiling water is poured on the *turbith*, in conſequence of which it becomes of a ſtill more lively yellow. The waſhing is repeated a third time, to deprive it of all the ſulphuric acid it contains. In this ſtate it has no longer any taſte, but is a mercurial oxyd, which, when urged by fire in a retort, gives out at firſt a little ſulphureous acid, and is then reduced into running mercury, giving out a great quantity of vital air[f]. Kunckel mentions this experiment, and it has been ſucceſsfully repeated by Monnet, Bucquet, and Lavoiſier, who have made it in the moſt accurate manner. I have alſo repeated it many times with ſucceſs. It proves, as we have obſerved, that the ſulphuric acid is formed of ſulphur, oxygen, and water; but a very violent fire is neceſſary to effect the reduction of the turbith. It is perhaps for want of a ſufficient heat that Baumé did not obtain mercury; and that he affirms, that it cannot be reduced to its metallic form, but by the addition of a combuſtible matter. The ſulphuric mercurial maſs being kept heated in the ſame retort in which it has been diſſolved, without unluting or waſhing the maſs to deprive it of the portion of acid, the decompoſition of the oxyd nevertheleſs takes place, and it is reduced into running mercury, in proportion as the oxygen, which it had taken from the ſulphuric acid, becomes an elaſtic fluid by the combination of heat and light.

The water which has been poured on the white ſulphuric mercurial maſs is loaded with a portion of the acid which was not decompoſed; but as oxyd of mercury is very ſoluble in that acid, a certain quantity is always taken up, ſo that the water holds in ſolution a true ſulphat of mercury. By evaporating moſt of the water, this ſalt is depoſited in ſmall needles, the form of which has not been determined, becauſe they are ſcarcely conſiſtent, and quickly attract humidity. When boiling water is thrown on the cryſtals of ſulphat of mercury, they become yellow, and in the ſtate of a mercurial oxyd, becauſe the water ſeparates the acid, which adheres but weakly, and leaves the oxyd pure. The ſame event happens when the water employed for the firſt waſhing of the mercurial maſs is moſtly evaporated, and the remainder is afterwards diluted by the addition of a large quantity of boiling water, inſtead of bringing it to cryſtals. A yellow powder is precipitated in the ſtate of a true oxyd. If cold water be uſed, the precipitate is white; but it immediately aſſumes a yellow colour by the addition of boiling water. In this manner the ſolution of the oxyd of mercury may be rendered decompoſable or not by water. For this purpoſe it is ſufficient to evaporate it nearly to cryſtallization, or to charge the acid with all the mercurial oxyd it is capable of diſſolving; for then the union of theſe two bodies is eaſily deſtroyed by water. If a ſmall quantity of acid be added, water is no longer capable of cauſing a precipitation. I obſerved this in the moſt ſatisfactory manner, by diſſolving well waſhed *turbith mineral* in weak ſulphuric acid; the ſolution is not ſaturated with mercurial oxyd, and is at the ſame time not precipitable by water. But if the ſolution be charged with as much turbith mineral as it can diſſolve by the aſſiſtance of heat, which may be done by adding that ſubſtance till it is no longer taken up, then the ſolution being poured into cold water, affords a white precipitate; or if into hot water, a yellow powder. In this ſtate, if a ſmall quantity of ſulphuric acid be added, it ceaſes to afford any precipitate. The white mercurial oxyd which the ſulphat of mercury depoſits when cold water is poured on it, is very ſoluble, and may be made to diſappear, by adding ſulphuric acid to the mixture [h].

Sulphat of mercury may be decompoſed by magneſia and lime, a yellow precipitate being depoſited; and fixed alkalis ſeparate an oxyd of mercury nearly of the ſame colour.

It muſt be obſerved, that theſe precipitates of mercury are variouſly coloured, according to the ſtate of the ſolution, and the nature of the precipitating ſubſtance; and their quantities likewiſe differ. They are very abundant when the ſolution is highly charged; and if, on the contrary, a ſolution which is not ſaturated with mercury be decompoſed, every portion of oxyd which is ſeparated by the firſt drops of the precipitant is rediſſolved by the exceſs of acid. But when that exceſs is ſaturated, the precipitate becomes permanent. Theſe different oxyds of mercury precipitated by alkaline ſubſtances are reducible in cloſe veſſels without addition. Ammoniac does not precipitate ſulphat of mercury when it contains an exceſs of acid; it forms a triple ſalt, or ammoniaco-mercurial ſulphat. When the ſulphat of mercury is properly neutralized, and without exceſs of acid, only a ſmall portion of black oxyd is ſeparated by the ammoniac, which it renders reducible by the contact of light alone. It forms a triple ſalt with the greater part of the ſulphat of mercury.

The nitric acid is decompoſed by mercury with the greateſt rapidity. The ſolution is effected without the application of external heat, and with various degrees of activity, according to the ſtate of the acid. The common aqua-fortis of the ſhops acts on mercury without emitting any conſiderable quantity of red vapours. If a ſmall quantity of fuming nitrous acid be added, or if the mixture be heated, the combination proceeds much more rapidly, and a very large quantity of nitrous gas is diſengaged. The mercury being reduced to an oxyd, remains diſſolved. The ſolution is at firſt green, in conſequence of a little nitrous gas which it holds in ſolution, but it loſes that colour at the end of a certain time. By this proceſs, the nitric acid takes up a quantity of mercury equal to its own weight. Bergman has obſerved, in his Diſſertation on the Analyſis of Waters, that nitric mercurial ſolutions differ from each other, according to the manner of their preparation; that which is made in the cold, and without the diſengagement of much red vapours, not being decompoſable by the addition of diſtilled water; but if the ſolution be aſſiſted by heat, and a large quantity of nitrous gas be produced, a precipitate will fall down on the addition of water. Such a ſolution cannot with certainty be made uſe of in the analyſis of mineral waters, as we ſhall hereafter obſerve. This phenomenon is, I apprehend, owing to the ſame cauſe in the nitrous as in the ſulphuric ſolution. Nitric acid, aſſiſted by heat, is capable of ſuperſaturating itſelf with oxyd of mercury, and holding it ſuſpended. This kind of ſolution, with exceſs of mercury, will be precipitated by diſtilled water, which changes the denſity of the liquor, and diminiſhes the adheſion of the mercurial oxyd to the nitric acid; the precipitate, therefore, is a true oxyd, which is very yellow, if warm water be poured on the ſuperſaturated ſolution, but is merely white if cold water be uſed. The yellow colour may, however, be inſtantly communicated by waſhing in warm water. But, on the other hand, as the ſolution made in the cold contains only mercurial nitrat, without an exceſs of oxyd, becauſe it cannot become charged with the oxyd which is ſuperabundant to its combination, but by means of heat, diſtilled water occaſions no precipitate. I think myſelf juſtified in accounting for the facts in this way, from a circumſtance which I have obſerved a great number of times, viz. that the ſame mercurial ſolution may be rendered decompoſable or not by water, accordingly as mercury or acid are added, and this may be repeated many times. For this purpoſe, mercury is to be diſſolved without heat in the nitric acid, in as large a quantity as can be taken up; this ſolution is not decompoſable by water, though nitrous gas has eſcaped; but if mercury be added to this by the aſſiſtance of heat, it becomes capable of affording a precipitate with water. By the ſame theory it is very evident that a nitric ſolution, which does not afford a precipitate by the addition of water, may acquire that property by ſimple heating. The heat, in fact, diſengages nitrous gas, and this diſengagement cannot be made without the deſtruction of a certain quantity of the acid. The proportion of mercurial oxyd to the remaining acid becomes of courſe greater, and the exceſs is no longer combined, but adheres to the nitrat of mercury, and is ſuſpended in ſuch a manner that water can precipitate it eaſily. I have aſcertained the fact that mercurial ſolutions afforded only the exceſs of oxyd united with a little nitric acid, by the addition of water, and do ſtill retain a portion of true nitrat of mercury, which may be decompoſed by alkalis, in the ſame manner as happens with the ſulphuric mercurial maſs waſhed for the preparation of *turbith mineral.* This portion of nitrat of mercury may even be brought to cryſtallize. The exceſs of mercurial oxyd, which renders the nitric ſolutions capable of being decompoſed by water, is likewiſe attended with a circumſtance which favours this decompoſition; it is, that the oxyd is ſo ſtrongly oxygenated, that it has but very little adherence with the nitric acid.

The ſolution of mercury in the nitric acid is exceedingly cauſtic, and capable of corroding and deſtroying our organs. When it falls on the ſkin, it forms ſpots of ſo deep a purple, that they appear black; theſe ſpots cannot be diſſipated but by the ſeparation of the epidermis, which ſcales off. The ſolution is uſed as a powerful eſcharotic in ſurgery, by the name of *mercurial water.* The ſolution of mercury in the nitric acid is capable of affording cryſtals, which differ from each other in their form, according to the ſtate of the ſolution, and the circumſtances accompanying the cryſtallization. Theſe varieties being carefully obſerved, appear to conſiſt of four diſtinct ſpecies, which I ſhall here deſcribe.

1. A ſolution made in the cold affords, by ſpontaneous evaporation, after ſeveral months, very regular tranſparent cryſtals. Romé de Liſle has deſcribed them accurately. They are flat ſolids, of fourteen faces, formed by the union of two tetrahedral pyramids, truncated very near their baſe, and likewiſe at the four angles, which reſult from the junction of the pyramids.

2. If the ſame ſolution made in the cold be evaporated and left to cool, it depoſits, in the courſe of 24 hours, a kind of very acute priſms ſtriated obliquely acroſs their length, which are formed by the ſucceſſive application of ſmall laminæ, placed ſlopewiſe upon each other, like tiles. (Botaniſts denote this by the term *imbricatim.*) On a near examination of the elements of theſe priſms, I found that the laminæ which compoſe them are ſolids, with fourteen faces, ſimilar to the cryſtals obtained by ſpontaneous evaporation, but ſmaller, and more irregular.

3. If a nitric ſolution be made by a mild and regulated heat, it affords, by cooling, cryſtals, in flat, very long, and very a-

cute needles, ſtriated lengthwiſe; theſe are the moſt commonly obtained, and have been deſcribed by the greateſt number of chemiſts, eſpecially by Macquer, Rouelle, Baumé, &c.

4. Laſtly, If this ſolution be more heated, ſo as to become decompoſable by water, it uſually takes the form of a white and irregularly formed maſs, ſimilar to the ſulphuric combination. In this circumſtance I have ſometimes had a confuſed aggregate of ſmall very long needles, of the appearance of ſatin, and flexible, which followed the motion of the liquor. They were perfectly ſimilar to the brilliant and ſilver coloured dendrites which I have often obſerved on the ſides of bottles, containing acetat of potaſh, or the *foliated earth of tartar*. It is proper to add, that this laſt ſolution, which affords only irregular and confuſed cryſtals, or ſhapeleſs maſſes, becauſe it contains much ſuperabundant oxyd of mercury, may be rendered capable of a more regular cryſtallization by the addition of acid.

Theſe ſeveral mercurial nitrats preſent nearly the ſame phenomena. They are very cauſtic, and corrode the ſkin in the ſame manner as their ſolutions; they detonate on burning coals. It muſt be obſerved with regard to this property, that it is much more ſenſible in the very regular cryſtals of fourteen facets, than in thoſe which have the form of ſmall needles; and that it does not exiſt at all in the white maſs precipitated from the ſtrongly heated ſolution. The detonation of mercurial nitrat is ſcarcely perceptible in cryſtals newly formed, but is rendered ſufficiently ſenſible by ſuffering them to dry for ſome time on blotting paper. If they be then placed on an ignited coal, they melt, become black, and extinguiſh the place on which they are put; but their borders, which become dry, throw out ſmall reddiſh ſparks, with a noiſe ſimilar to that of a ſlight decrepitation. When the very dry cryſtals are uſed, a ſtronger whitiſh flame eſcapes, which ſoon ceaſes.

The nitrat of mercury melts when heated in a crucible, and emits very thick red vapours. In proportion as it loſes its water and nitrous gas, it takes a deeper yellow colour, which is afterwards converted to an orange, and laſtly to a brilliant red. In this ſtate it is called *red precipitate*. We term it *red oxyd of mercury by the nitric acid*. If this preparation is intended to be employed in ſurgery as a cauſtic, it muſt be made in a matraſs by a mild heat, in order that it may retain a portion of the acid, to which it owes its corroſive power. Nothing remains after it has been ſtrongly heated, but an oxyd of mercury, formed by the union of the metal to the oxygen of the nitric acid. Mercurial nitrat diſtilled in a retort affords a ſubacid phlegm, and nitrous gas at firſt, after which it becomes *red precipitate;* and a ſtronger heat being applied, occaſions a large quantity of vital air, with a ſmall portion of azotic gas to be diſengaged, the mercury being ſublimed in the metallic form. It is from this experiment, made with the greateſt accuracy, that Lavoiſier has ſucceeded in proving the compoſition of the nitric acid, as we have obſerved in the hiſtory of that acid.

Nitrat of mercury becomes yellowiſh on expoſure to air, and is very ſlowly decompoſed. It is ſoluble in diſtilled water, in a larger quantity when boiling than in the cold, and conſequently cryſtallizes by cooling. When this ſalt is diſſolved in water, a portion remains, which is of a yellowiſh colour, and is not taken up. Monnet calls this matter *nitrous turbith*, and obſerves, that a large quantity may be obtained by waſhing a nitric mercurial maſs, evaporated to dryneſs, ſuch as is made for the preparation of *red precipitate.* If it be intended that the mercurial nitrat ſhall be entirely diſſolved, water muſt be employed, in which aqua-fortis muſt be poured, until the precipitate diſappears. I have obſerved, when boiling water is poured on the pureſt nitrat of mercury, it immediately becomes yellow, and affords an oxyd of a deep colour, which, when expoſed to fire, becomes red more quickly than that which is made by the ſulphuric acid. The yellow oxyd of mercury by the nitric acid is in general more accurately oxydated than that which is prepared by the ſulphuric acid; which happens, as we have already obſerved reſpecting other combuſtible ſubſtances, from the nitric acid ſuffering its oxygen to be diſengaged more eaſily than the ſulphuric acid.

Barytes, magneſia, lime, and alkalis, decompoſe nitrat of mercury, and precipitate the metal in the ſtate of oxyd. Theſe precipitates are of different colours, weight, and quantity, according to the ſtate of the ſolution. Cauſtic fixed alkalis afford a yellow precipitate, more or leſs brown, or of a brick colour, according as their cauſticity is more perfect. Ammoniac precipitates the nitric mercurial ſolution, of a grey ſlate colour, provided it be of that kind which water cannot decompoſe; but the ſame ſalt produces a white precipitate, in a ſaturated ſolution of mercury, ſuch as water can precipitate. Theſe differences have been accurately obſerved by Bergman. The precipitates are mere oxyds of mercury, more or leſs oxygenated; they are all reducible without addition, and by mere heat in cloſed veſſels, and all afford pure air during their reduction[i]. Thoſe which have been precipitated by alkaline carbonats afford a certain quantity of carbonic acid by the action of heat. Thoſe which, without having been precipitated by carbonats, have been merely expoſed to the contact of atmoſpherical air, exhibit the ſame phenomenon, becauſe they always abſorb this acid from the atmoſphere; a property common to all the oxyds of mercury, and even to thoſe of ſeveral other metals. The oxyds of mercury, by alkaline intermediums, have a property, diſcovered by Bayen, which muſt not be paſſed over in ſilence. They detonate like gunpowder, when expoſed in an iron ſpoon to a gradual heat, after having been triturated in the quantity of half a drachm, with ſix grains of flowers of ſulphur; after the detonation a violet coloured powder remains, which may be ſublimed into cinnabar.

The ſulphuric acid, and the ſalts into which it enters, likewiſe decompoſe nitrat of mercury on account of the ſtronger affinity of the ſulphuric acid to mercury. If ſulphuric acid, or a ſolution of ſulphats of potaſh, ſoda, &c. or of any other ſulphuric ſalt, be poured into a ſolution of mercurial nitrat, a whitiſh precipitate is formed, if the nitric ſolution be not ſaturated; but it is yellower in proportion as the nitrat of mercury contains leſs acid, and more mercurial oxyd. This precipitate is ſulphat of mercury neutralized in the firſt inſtance, and with exceſs of oxyd in the ſecond. Bayen found that it always retains a portion of nitric acid.

The muriatic acid has no ſenſible action on mercury, though it be one of thoſe which has the ſtrongeſt affinity with the oxyd of that metal; but its action on mercurial oxyd, with which it forms a peculiar neutral ſalt, is very powerful. This combination takes place whenever the muriatic acid is brought into contact with the oxyd, in a ſtate of extreme diviſion. If a ſmall quantity of muriatic acid be poured on a nitric ſolution of mercury, this acid ſeizes the oxyd of the metal, and forms a ſalt which is precipitated in a kind of whitiſh coagulum, called *white precipitate*; the muriatic ſalts, with baſe of alkali, or of any ſalino-terreſtrial ſubſtance, abundantly produce the ſame effect, and form beſides nitric ſalts, differing according to the nature of the baſe. But it muſt be obſerved, with reſpect to this precipitation, that it does not take place when the oxygenated muriatic acid is uſed; becauſe though this acid takes the oxyd of mercury from the nitric acid, the ſalt which it forms with that oxyd is very ſoluble in water; whereas the ſalt formed by the common muriatic acid is not at all ſoluble.

This acid has a ſtronger affinity than the ſulphuric acid with the oxyd of mercury, and occaſions the ſame precipitate in the ſulphuric ſolutions of that metal, as it does in the nitric ſolutions. The compound of muriatic acid and oxyd of mercury may exiſt in two ſtates, as we have before obſerved, according to the ſimple or oxygenated ſtate of the acid; the latter conſtitutes the oxygenated muriat, or *corroſive*, and the former the *mild* mercurial muriat.

There are ſeveral proceſſes for preparing *corroſive ſublimate*, or corroſive mercurial muriat; in general, equal parts of dried mercurial nitrat, decrepitated muriat of ſoda, and calcined ſulphat of iron, or white *martial vitriol*, are mixed and put into a matraſs, two thirds of whoſe capacity are left empty. This veſſel is plunged into a ſand bath, and gradually heated till its bottom becomes of an obſcure red; the ſulphuric acid diſengages the muriatic acid from the ſoda; the latter ſeparates the mercury from the nitrous acid, from which it takes a portion of its oxygen, ſo that it becomes oxygenated muriatic acid; it then combines with the oxyd of mercury and forms corroſive mercurial muriat, which is ſublimed in the form of flattened and pointed cryſtals to the upper part of the matraſs; the nitric acid being diſſipated in the form of nitrous gas. The reſidue is reddiſh or brown, and contains oxyd of iron, and ſulphat of ſoda, formed by the union of the ſulphuric acid with the baſe of the marine ſalt. This ſalt is prepared in the large way in Holland, by triturating equal parts of mercury, muriat of ſoda, and ſulphat of iron together, and expoſing the maſs to a violent fire. In this operation the oxyd of iron, deprived of the ſulphuric acid by heat, and highly oxygenated, appears to cauſe the muriatic acid to paſs into the oxygenated ſtate, ſince this laſt only is preſent in ſufficient quantity perfectly to diſſolve the mercury made uſe of. The corroſive mercurial muriat may likewiſe be obtained by ſublimation, from mixtures of ſulphat of iron, muriat of ſoda, and mercurial precipitates, by fixed alkalis, or from every kind of oxyd of mercury.

Boulduc has given a very good proceſs for preparing corroſive mercurial muriat; but Spielman remarks, that it was before deſcribed by Kunckel in his *Chemical Laboratory*. It conſiſts in heating equal quantities of ſulphat of mercury, and decrepitated muriat of ſoda in a matraſs; the muriat of mercury is volatilized, and the reſidue conſiſts of ſulphat of ſoda. This method affords a very pure corroſive ſublimate; whereas that uſed in commerce, and even that prepared in the ſmall way, with ſulphat of iron, always contains a ſmall quantity of this metal. It is likewiſe more eaſy to execute, and more economical. We muſt here obſerve, that this operation proves that the ſulphuric acid has the property of oxygenating the muriatic acid. Monnet affirms, that he has likewiſe obtained this ſalt, by treating, in a retort, very dry muriat of ſoda and mercurial oxyd, precipitated from its nitrous ſolution by fixed alkali. In all theſe preparations of mercurial corroſive muriat, care muſt be taken not to break the ſublimatory veſſel till it is entirely cool, in order to avoid the vapours of the ſublimed ſalt. Laſtly, There is another way of preparing the corroſive mercurial muriat more readily; it conſiſts in pouring into a ſolution of nitrat of mercury a quantity of oxygenated muriatic acid, and evaporating ſlowly the mixture. When the nitrous acid is diſengaged the liquor affords, by cooling, cryſtals of corroſive mercurial muriat. There is reaſon to think that when the oxygenated muriatic acid of Scheele ſhall be better known, the corroſive mercurial muriat of the ſhops will be prepared by this ſimple ſolution.

Corroſive mercurial muriat is a neutral ſaline ſubſtance which deſerves to be carefully attended to by chemiſts and phyſicians; it poſſeſſes a great number of properties which are highly neceſſary to be known, and of which we ſhall proceed to give a ſketch. Its taſte is exceedingly cauſtic; the ſmalleſt quantity being laid upon the tongue, leaves for a very long time an highly diſagreeable ſtyptic and metallic taſte. This impreſſion is carried even to the larynx, which it contracts ſpaſmodically for a long time, eſpecially in delicate perſons. The action of this ſalt is ſtill ſtronger on the tunics of the ſtomach and the inteſtines. When it is applied to theſe for any length of time, it corrodes them, and deſtroys their ſubſtance, for which reaſon it is one of the moſt violent poiſons we know. The cauſticity of corroſive mercurial muriat appears to depend on the ſtate of the mercury, as Macquer has very ingeniouſly obſerved. It cannot be attributed to the muriatic acid, as ſome authors have thought; for the mercury is more than treble the quantity of the acid. On this account the ſalt renders ſyrup of violets green, rather than red, according to the obſervation of Rouelle. The taſte of corroſive mercurial muriat is beſides exceſſively ſtronger than that of the muriatic acid. A drachm of ſpirit of ſalt, diluted with water, may be taken with impunity; whereas a few grains of corroſive mercurial muriat, diſſolved in the ſame quantity of water, would poiſon without remedy. Bucquet thought that this extreme ſtrength of taſte depended on the combination of the two bodies, and from thence deduced one of his ſtrongeſt proofs of the law of affinity, which eſtabliſhes, that compounds have new properties, very different from thoſe of either of their component parts.

Corroſive mercurial muriat is not ſenſibly altered by light; heat volatilizes, and ſemi-vitrifies it. If it be ſtrongly heated with acceſs of air, it is diſſipated in the form of a white fume, whoſe effects on the animal economy are very active, and exceedingly dangerous. When heated ſlowly, and by degrees, it ſublimes in a cryſtalline and regular form, into priſms, ſo flattened that it is impoſſible to determine the number of their faces. They terminate in very acute ſummits, and have been very properly compared to the blades of poniards thrown confuſedly among each other. Fire alone is not capable of decompoſing this ſalt, neither is it ſuſceptible of alteration from the air. It is ſoluble in nineteen parts of water, and cryſtallizes by evaporation, in flattened priſms, very ſharp, their extremity being ſimilar to thoſe obtained by ſublimation. The ſpontaneous evaporation of this ſolution has ſeveral times afforded me oblique angled parallelopipeds, whoſe extremities were truncated ſlant-wiſe. Bucquet obſerved the ſame fact. Thouvenel has obtained cryſtals of this ſalt, in hexahedral priſms, a little flattened.

Barytes, magneſia, and lime, decompoſe the corroſive mercurial muriat, and precipitate the mercurial oxyd. The *phagedenic water* made uſe of as a corroſive by ſurgeons, is made by throwing half a drachm of this ſalt, in powder, into a pound of lime-water; a yellow precipitate is formed, which renders the fluid opake, and it is employed before this ſubſides. Fixed alkalis precipitate from corroſive mercurial muriat, an orange coloured oxyd which becomes deeper coloured by keeping. Ammoniac affords a white precipitate, which after a ſhort time becomes of a ſlate colour[k].

Acids and neutral alkaline ſalts, produce no change in the corroſive mercurial muriat. This ſalt contracts an intimate union with muriat of ammoniac without decompoſition. This very ſingular ſaline compound, which was highly eſteemed by the alchemiſts, and called by them *ſal alembroth*, *ſalt of art*, *or of wiſdom*, &c. is formed either by ſublimation or cryſtallization. The ammoniacal muriat renders the corroſive mercurial muriat very ſoluble, ſince, according to Baumé, three ounces of water charged with nine drachms of the former, diſſolves five ounces of the latter ſalt. This ſolution is made with heat, and affords a ſolid maſs in cooling. A preparation, called *white mercurial precipitate*, is made from this ſalt. A pound of corroſive mercurial muriat in powder is thrown into a ſolution of the ſame quantity of muriat of ammoniac; when the ſalt is perfectly diſſolved a ſolution of carbonat of potaſh is added, which forms a white precipitate, which is waſhed and dried in the form of ſmall lozenges. In this operation the potaſh diſengages the ammoniac, which precipitates the mercury in a white oxyd. Heat, and even light, gives this precipitate a yellow colour.

Corroſive mercurial muriat is altered by hydrogen gas. Sulphur does not change it, but alkaline ſulphure decompoſes this as well as all the other ſolutions of mercury; a black precipitate being produced, which ariſes from the combination of the ſulphur with the mercury. Moſt of the metals we have mentioned are capable of decompoſing this ſalt, and each decompoſition exhibits peculiar phenomena, which well deſerve to be examined.

If two parts of corroſive mercurial muriat, with one of arſenic, be diſtilled by a mild heat, a tranſparent ſubſtance, of the conſiſtence of oil, paſſes into the receiver, part of which ſoon condenſes into a kind of white jelly, called *corroſive oil*, or *butter of arſenic*. If the heat be continued after the butter has paſſed over, running mercury is obtained; ſo that the proceſs affords a method of determining accurately the principles of corroſive mercurial muriat. The muriat of arſenic does not appear capable of cryſtallization, melts with gentle heat, and is ſo cauſtic that it inſtantly deſtroys the organs of animals. It is ſoluble in water, which partly decompoſes it; but its other properties are unknown. Oxyd of arſenic does not afford it, becauſe in this ſtate the metal being already combined with a portion of oxygen, cannot take it from the oxyd of the mercury, nor diſengage the mercury from its muriatic combination.

The effects of cobalt, nickel, and manganeſe, on corroſive mercurial muriat, have not been examined. Biſmuth, antimony, and zink, decompoſe this laſt ſalt with great facility. When two parts of corroſive mercurial muriat and one part of biſmuth are diſtilled together, a thick fluid ſubſtance is obtained, which congeals into a maſs of a greaſy appearance, fuſible by heat, and precipitable by waſhing with much water; and in a word, a true ſolid muriat of biſmuth. Poli, who firſt deſcribed this experiment, in the Hiſtory of the Royal Academy for the year 1713, affirms, that when this *butter* of biſmuth is ſublimed ſeveral times, there remains in the veſſel a powder of the colour of oriental pearls, very ſoft to the touch, and as it were glutinous; he propoſes this powder to be employed as a pigment.

If twelve ounces of antimony, and two pounds of corroſive mercurial muriat, be accurately mixed together, heat is excited, which ſhows that there is a rapid action between them. If the mixture be diſtilled by a gentle heat, a thick liquor is obtained, which becomes fixed in the receiver, and often in the neck of the retort, in the form of a white maſs, called *butter of antimony*. This ſublimed muriat of antimony uſually weighs ſixteen ounces and a few drachms. The reſidue is compoſed of mercury, and a grey powder of antimony, which floats on the metallic fluid. If the diſtillation be continued after the muriat of antimony has paſſed over, a new receiver being adapted, running mercury is obtained, ſoiled by a ſmall quantity of the muriat of antimony, which it is impoſſible to clear entirely out of the neck of the retort. Baumé, who has accurately deſcribed this operation, affirms, that by this proceſs two ounces of running mercury may be obtained, one ounce of antimony in powder, mixed with the mercury, and ſix drachms twenty-four grains of antimony melted in the retort. The latter is partly oxydated, it affords a red oxyd and a white, in part ſublimed. In this experiment the antimony is oxydated by the oxygen which is ſeparated from the oxyd of mercury, and unites to the muriatic acid, with which it forms the muriat of antimony. The ſame decompoſition takes place equally well with ſulphure of antimony; one part of that mineral in powder being diſtilled with two parts of corroſive mercurial muriat, affording a ſublimed muriat of antimony. But the reſidue, inſtead of containing running mercury, exhibits a combination of ſulphur with that ſemi-metal. This combination may be ſublimed by a ſtronger fire into red needles, improperly called *cinnabar of antimony*.

This ſublimed muriat of antimony, or the combination of the muriatic acid with antimony, does not take place but in proportion as the ſemi-metal takes the oxygen from the mercury, as we have already obſerved of arſenic. This compound is in a ſolid form; it cryſtallizes in thick parallelopipeds; its cauſticity is ſufficiently ſtrong to deſtroy both animal and vegetable matters in a very ſhort time. The action of light changes it: by a low heat it is melted, and becomes fixed by cooling; for which reaſon it has been called *butter* of antimony. It is eaſily deprived of its white colour; and it may be rectified by diſtillation. When expoſed to the air it attracts moiſture, and is diſſolved into a thick fluid, apparently oleaginous: it does not completely diſſolve in water, the greater part being decompoſed by that fluid. When ſublimated muriat of antimony is thrown into diſtilled water, a very abundant precipitate is immediately formed, which is known by the name of *emetic powder*, or *powder of Algaroth*, from the name of an Italian phyſician who firſt uſed it. It has been improperly called *mercurius vitæ*. This precipitate is an oxyd of antimony which is violently purgative and emetic in a ſmall doſe, as for example, three or four grains. In order to obtain it very pure it muſt be waſhed ſeveral ſucceſſive times in diſtilled water. Its properties are different from the other oxyds of this metal, which have not ſo ſtrong an action on the animal economy. A portion of this oxyd remains diſſolved in the water uſed in waſhing the muriat of antimony, in which it is ſuſpended by the acid taken up by that fluid. This fact may be aſcertained by the addition of a ſmall quantity of alkali, which occaſions an abundant white precipitate. It is therefore the exceſs of oxyd with which butter of antimony is charged, that gives it the property of being decompoſed by water, as well as that of taking the form of a ſolid maſs. The ſublimated muriat of antimony diſſolves with heat and efferveſcence in the nitric acid; a large quantity of nitrous gas being at the ſame time diſengaged with conſiderable agitation of the fluid. The muriat of antimony diſappears, and the liquid becomes of a yellow reddiſh colour. It is a ſolution of oxyd of antimony in nitro-muriatic acid. The oxyd is ſoon depoſited in the form of a powder, or white magma. If the ſolution of muriat of antimony by the nitric acid be evaporated to dryneſs immediately after it is made, a very white oxyd is obtained. This oxyd is diluted with its own weight of the ſame acid, which is likewiſe evaporated, and the ſame proceſs is a third time repeated; after which the matter is calcined in a crucible kept red hot for about half an hour, and affords an oxyd, which, when cold, is found to be white on the upper part, and of a roſe colour below. Theſe two portions mixed together conſtitute the preparation called *Bezoar mineral.* Macquer conſiders it as a perfect oxyd of antimony, and thinks it abſolutely fimilar to *diaphoretic antimony.* But Lemery, who has carefully deſcribed this preparation, recommends that it ſhould be calcined till it has but a very ſlight degree of acidity; his intention therefore is, that it ſhould retain a certain quantity of acid, which muſt neceſſarily change the properties of the oxyd of antimony.

Corroſive mercurial muriat is decompoſed by zink, as Pott informs us, and as I have myſelf many times experienced. If a mixture of two parts of this ſalt, with one part of zink in filings, or coarſe powder, be diſtilled in a glaſs retort, a very white and ſolid ſalt ariſes, which cryſtallizes in ſmall united needles, ſimilar to the aggregates of which ſtalactites are compoſed. The mercury remains pure in the retort, and paſſes over after the ſalt. This muriat of zink fumes ſlightly when taken out of the receiver, and melts with a mild heat, becomes coloured by inflammable vapours, and is partly decompoſed by water, like the ſublimed muriat of antimony.

The moſt ſingular property of corroſive mercurial muriat, relative to its alteration by metallic ſubſtances, and at the ſame time the moſt important of its properties is its combination with running mercury. When ſaturated with this metallic fluid, it loſes moſt of its properties, eſpecially in its taſte and ſolubility. To make this combination, corroſive mercurial muriat was formerly triturated in a glaſs mortar with running mercury, added by a little at a time, till no more could be made to diſappear. The quantity of mercury, which the ſalt takes up by this proceſs, amounts to three-fourths of its weight, as Lemery and Baumé have obſerved. The mixture was placed in ſmall veſſels, two-thirds of which were left empty, and in this manner ſublimed three times ſucceſſively, care being taken each time to ſeparate a white powder which is found beneath the ſublimed matter, and is very corroſive. The product called *ſweet ſublimate, mercurius dulcis, or aquila alba,* or more properly mild mercurial muriat, differs from the corroſive by its inſolubility in water, by its inſipidity, and by its cryſtalline form. The cryſtals obtained by ſlow ſublimation, are tetrahedral priſms, terminated by four ſided pyramids; two very long and tetrahedral pyramids are frequently united at their baſe, and form a very acute octahedron.

The proceſs we have deſcribed for the preparation of mercurius dulcis, is inconvenient in many reſpects. The trituration of corroſive mercurial muriat with running mercury, till the latter diſappears, is very tedious and difficult; and at the ſame time a ſubtle powder riſes of ſo pernicious a quality, that the operator is under the neceſſity of covering his mouth and noſe with a cloth. The mercury is never abſolutely made to diſappear in the mortar, and the ſublimations are very ſlow. Baumé adviſes a ſmall quantity of water to be poured on the matters intended to be triturated; by this means the operation is rendered more eaſy, and the ſaline powder is prevented from riſing. He likewiſe employs levigation, by which the extinction of mercury is greatly facilitated. Laſtly, In order to be certain of obtaining the mild mercurial muriat entirely free from the corroſive, Zwelfer, Cartheuſer, and Baumé, propoſe to pour on the mild mercurial muriat a quantity of warm water, in order to diſſolve the corroſive muriat, and afterwards to dry the portion of mild mercurial muriat, which is then found to be very mild. Cornet, to avoid the noxious duſt of the mercurial corroſive muriat, when triturated with mercury, propoſes to uſe the precipitate of nitrat of mercury by ammoniac, which unites much better to corroſive mercurial muriat than running mercury; but this oxyd not being as pure as mercury, the preparation into which it enters cannot be ſo much depended on. Bailleau, apothecary at Paris, has communicated to the Royal Society of Medicine, a proceſs for making mild mercurial muriat, which is free from the imperfections and danger of the common methods. It conſiſts in forming a paſte of corroſive mercurial muriat and water, and triturating it with running mercury; the trituration in the courſe of half an hour cauſes the mercury to diſappear, becauſe the water promotes its comminution, and the combination is completed by digeſting the mixture on a ſand bath with a mild heat. The matter, which at firſt is grey, becomes white, and forms a very mild mercurial muriat, which requires only one ſublimation to render it perfectly pure [1].

Baumé has made many experiments on mild mercurial muriat. He has proved that this compound cannot be charged with a larger quantity of mercury, and that it cannot exiſt in a middle ſtate, between that of corroſive mercurial muriat, and mild muriat; ſo that when a ſmaller quantity of mercury is mixed with corroſive mercurial muriat than is neceſſary to cauſe it to paſs to the ſtate of the mild muriat, this laſt compound is formed in quantities proportioned to the doſe of mercury added; and the reſt of the corroſive mercurial muriat is volatilized with all its properties, without being rendered at all milder. The two compounds may be ſeparated by means of warm water.

The experiments of the ſame chemiſt likewiſe teach us, that it is poſſible to change the mild mercurial muriat into corroſive, by ſubliming it with decrepitated muriat of ſoda and ſulphat of iron, calcined to whiteneſs. In this operation the muriatic acid, being diſengaged and oxygenated by the ſulphuric acid, ſeizes the oxyd of the mild mercurial muriat, and converts it into corroſive muriat. Baumé has aſcertained another circumſtance, which ſhows the great difference between the mild mercurial muriat and the corroſive; namely, that it does not unite with ammoniacal muriat, as corroſive mercurial muriat does, in the preparation of *ſal-alembroth*, or the ammoniaco-mercurial muriat. He therefore adviſes the waſhing of mild mercurial muriat with water charged with a ſmall quantity of ammoniacal muriat, in order that all the corroſive mercurial muriat, which is rendered very ſoluble by this ſalt, may be carried off. Laſtly, He has diſcovered, that at each ſublimation the mild mercurial muriat loſes a portion of mercury, and conſequently affords a ſmall quantity of corroſive mercurial muriat; ſo that by repeated ſublimations, mild muriat may be entirely changed into corroſive. From this laſt experiment it obviouſly follows, that the preparation known under the name of *panacea mercurialis*, which is made by ſubliming mild mercurial muriat nine times, is ſo far from being rendered milder by theſe operations, as moſt chemiſts and phyſicians have ſuppoſed, that it does not at all differ from what it was at firſt. This laſt aſſertion is eſtabliſhed the more incontrovertibly, by the circumſtance of its being neceſſary to ſeparate a white powder which riſes the firſt in each ſublimation, and is in fact corroſive mercurial muriat. It muſt be obſerved, that in the preparation of mild mercurial muriat, a reddiſh powder remains in the bottles, which is an oxyd of iron, afforded by the ſulphat of iron uſed in the common method of making corroſive mercurial muriat for ſale. A portion of this oxyd riſes with the ſalt in ſublimation. Small pieces of glaſs are likewiſe not unfrequently found, which have been carried up by the vapours of the corroſive mercurial muriat.

The modern experiments made on the oxygenated muriatic acid, tend greatly to explain the theory of the formation of mild mercurial muriat. It is now proved, that corroſive mercurial muriat is a compound of oxygenated muriatic acid, and the oxyd of mercury, and that mild mercurial muriat is formed by common muriatic acid, in combination with the ſame metallic oxyd, or, which is the ſame thing, that the oxyd is much more calcined or *oxydated* in the corroſive muriat than in the mild. So that when running mercury is triturated with corroſive mercurial muriat, the mercury ſeizes the exceſs of oxygen of the muriatic acid, or that of the former mercurial oxyd; and the more conſiderable doſe of new oxyd leſs calcined, which unites to the muriatic acid, cauſes the nature of the ſalt to vary, which becomes leſs ſaline, leſs ſapid, leſs ſoluble, and, in a word, in which the properties communicated to the mercury by the oxygen, are weakened in proportion as the quantity of that principle is diminiſhed.

The boracic acid does not immediately diſſolve mercury, but it has a very evident action on this metal, when in the ſtate of an oxyd. Theſe two ſubſtances may be combined by the way of double affinity. A ſolution of borax being poured into a nitric ſolution of mercury, an abundant yellow precipitate is formed, as Monnet firſt obſerved. In this operation the ſoda of the borax unites with the nitric acid, and forms nitrat of ſoda, while the acid of the borax combines with the oxyd of mercury, in the form of a neutral ſalt, which being ſparingly ſoluble, falls down. The filtrated liquor affords, by evaporation, fine and brilliant pellicles of mercurial borat. It muſt be obſerved, however, that this ſalt contains a portion of the oxyd of mercury, which is not combined with the acid of borax, becauſe of the ſoda, which is in exceſs in the borax of commerce. If pure borat of mercury be required to be had by this proceſs, it will be neceſſary to employ a borat of ſoda perfectly neutral; that is to ſay, the borax of commerce, ſaturated with as much of the boracic acid as it can take up. This ſalt, by expoſure to the air, becomes gradually of a greeniſh hue. Ammoniacal muriat renders this ſalt very ſoluble, and forms with it a compound, analogous to the ammoniaco-mercurial muriat; lime-water throws down a yellow precipitate, which changes to deep red, and potaſh cauſes a white precipitate. According to the academicians of Dijon, the corroſive mercurial muriat is likewiſe decompoſed by borax, which produces in its ſolution a precipitate of a brick-duſt colour. Water, boiled on this precipitate, becomes of a milky colour, by the addition of fixed alkali, which proves that it contains mercurial borat.

The action of the fluoric acid on mercury is not known, and that of the carbonic acid is almoſt equally uncertain. It is only known, that water impregnated with this acid does not attack this metal; but the ſolution of mercury decompoſed by alkaline carbonats afford precipitates very different from thoſe produced by the ſame ſubſtances when pure and cauſtic, though the oxyds of mercury abſorb, with conſiderable efficacy, the carbonic acid contained in the atmoſphere[m].

Neutral ſalts have ſcarcely any action on mercury. Though this aſſertion is more eſpecially applicable to the different ſulphats, I have obſerved, neverthleſs, that mercury becomes very quickly extinguiſhed in ſulphat of potaſh.

Mercury does not appear capable of altering ammoniacal muriat by diſtillation. Bucquet, who made this experiment, obſerved, that two parts of mercury are not well extinguiſhed by one part of this ſalt, and that the mixture does not afford ammoniac by diſtillation. The Count de la Garaye, nevertheleſs, prepared with theſe two ſubſtances, a medicine, to which he gave the name of *tincture of mercury*. Macquer, who examined his proceſs, found it to ſucceed perfectly well. It conſiſted in triturating one ounce of running mercury, with four ounces of ammoniacal muriat, in a marble mortar, moiſtening the mixture with a ſmall quantity of water, till the mercury entirely diſappeared. This matter being left expoſed to the air five or ſix weeks, and from time to time agitated, is then to be triturated afreſh, and afterwards expoſed in a matraſs on a ſand bath, covering the powder to the depth of about two inches with good ſpirit of wine. The mixture being made to boil ſlowly, the ſpirit of wine aſſumes a yellow colour, and contains mercury, as appears from its whitening a ſlip of copper. From this experiment it appears, that the ammoniac is gradually diſengaged by the mercury; that ammoniaco-mercurial muriat is formed, part of which is diſſolved by the ſpirit of wine; and that the different quantity of the mercury, and the ſlow action produced during the maceration, are the cauſes of the difference between this experiment and that of Bucquet.

The action of hydrogen gas on mercury is not known.

Mercury combines very readily with ſulphur. When one part of this metallic fluid is triturated with three parts of ſulphur, the mercury is gradually extinguiſhed, and a black powder is produced, being the black ſulphure of mercury, which is called *Æthiops Mineral*, and whoſe colour becomes deeper ſome time after it is made. This combination is more quickly effected, by mixing mercury with melted ſulphur. The mixture being ſtirred up immediately, becomes black, and very readily takes fire. In order to preſerve it black, it muſt be taken from the fire, the flame extinguiſhed as ſoon as it begins to appear, and the matter muſt be ſtirred till it becomes ſolid, and in lumps. It muſt then be pulverized, and paſſed through a fine ſieve. The black ſulphure of mercury is not the moſt intimate combination which ſulphur and mercury are capable of forming. When this compound is expoſed to a conſiderable degree of heat, it takes fire, the greateſt part of the ſulphur burns, and after the combuſtion a matter remains, which, when pulverized, is of a violet colour. This powder is put into matraſſes, which are heated till their bottoms become red, and kept in this ſtate for ſeveral hours, till it appears that the matter is entirely ſublimed. An artificial cinnabar, or red ſulphure of mercury, is found ſublimed to the upper part of the matraſs, in cryſtalline needles, of a reddiſh brown. It is of a lighter and more lively colour, when ſublimed in retorts. The Dutch prepare in the large way the cinnabar employed in the arts; the compound is not volatile, but requires a ſtrong fire to ſublime it. When much divided by levigation, it has a brilliant red colour, and is then called *vermillion.* If it be heated in open veſſels, the ſulphur, which is not equal to one fourth of its weight, burns gradually, and the mercury is volatilized. Many ſubſtances are capable of decompoſing red ſulphure of mercury, by virtue of their affinity to ſulphur. Lime and alkalis have this property; when theſe are heated in a retort, with twice their weight of cinnabar, running mercury is obtained, and the reſidue is found to be an alkaline, or earthy ſulphure. Baumé has obſerved, that this decompoſition takes place by the humid way, when red ſulphure of mercury is boiled with a ſolution of fixed alkali. It muſt be obſerved, that he employed the alkaline carbonat. Many brittle metals, ſuch as cobalt, biſmuth, and antimony, have likewiſe the property of depriving mercury of its ſulphur. It will be hereafter ſeen, that almoſt all the ductile metals, lead, tin, iron, copper, and ſilver, have likewiſe a ſtronger affinity with ſulphur than mercury, and conſequently decompoſe *cinnabar*. They may therefore be indifferently uſed, to ſeparate the mercury from this compound. The metallic fluid obtained by theſe proceſſes is perfectly pure, and is diſtinguiſhed by the name of *mercury revived from cinnabar.*

Mercury immediately decompoſes alkaline ſulphures, but produces different phenomena, according to the nature of theſe compounds. It forms with alkaline ſulphures black ſulphure of mercury, which, in the courſe of ſeveral years, becomes red. With the ammoniacal ſulphure, it very quickly becomes converted into black ſulphure of mercury, and in a few hours, or at moſt a few days, it aſſumes a brilliant red colour. The yellow and red oxyds of mercury made by the fire, or by acids, exhibit the ſame phenomenon, more or leſs readily, with the ammoniacal ſulphure. It is likewiſe produced by pouring this liquor into ſolutions of mercury, and expoſing the black precipitate, which reſults from theſe mixtures, to a new quantity of ammoniacal ſulphure.

I have diſcovered, that running mercury, agitated in water, impregnated with ſulphurated hydrogen gas, whether naturally or artificially, decompoſes it very readily, and is changed into black ſulphure.

The action of mercury on arſenic is not known. Cobalt does not unite with it. Mercury diſſolves biſmuth very readily, with which it combines in all proportions: from this combination a brilliant friable matter is produced, which is more or leſs ſolid, according to the quantity of biſmuth it contains. This amalgam is capable of cryſtallizing in four-ſided pyramids, which ſometimes unite together in octahedrons. But it moſt commonly cryſtallizes in thin laminæ, which have no regular form. This cryſtallization is obtained by melting the combination, and ſuffering it to cool ſlowly. When it is heated in a retort, it does not part with its mercury but with great difficulty.

Mercury does not unite either to nickel, or to antimony. It combines with zink by fuſion. The amalgam formed with this laſt metal is ſolid, but becomes fluid by trituration. When melted, and ſuffered to cool ſlowly, it cryſtallizes in laminæ, which appear ſquare with rounded edges.

Mercury is of the moſt extenſive uſe in the arts, ſuch as gilding, ſilvering of glaſſes, conſtructing of meteorological inſtruments, metallurgy, &c. it is uſed in medicine in a great variety of forms.

1. Crude mercury was formerly employed in the iliac paſſion. It is ſtill boiled in water, to which it communicates a vermifuge property. Mixed with fat ſubſtances, it forms an ointment uſed in venereal diſorders.

2. *Turbith mineral*, or yellow oxyd of mercury by ſulphuric acid has likewiſe been recommended in the ſame diſorders, in the doſe of a few grains. This medicine is emetic and purgative in a high degree.

3. Mercurial water, or its nitric ſolution, is uſed by ſurgeons as a powerful eſcharotic. Red precipitate, or red oxyd by the nitric acid, anſwers the ſame purpoſe. A citron coloured ointment is prepared with hog's lard and the nitric ſolution of mercury, which is a certain cure for the itch.

4. Corroſive mercurial muriat has been recommended by Sanchès and Van Swieten, in venereal diſorders. A few grains are diſſolved in brandy, and a ſpoonful of this ſolution is taken at a time in a large quantity of mild liquid. The exhibition of this remedy requires great care, more eſpecially with regard to the ſtate of the ſtomach and lungs. Mild mer-

curial muriat, given in the doſe of twelve or fifteen grains, is a purgative, and in the doſe of three or four grains, is an alterative. The phagedenic water is uſed in ſurgery to corrode and deſtroy fungus, or *proud fleſh*, &c.

5. Mercurial borat has been uſed with ſucceſs in venereal diſorders by Chauſſier the younger, of the academy of Dijon.

6. *Cinnabar* has been conſidered improperly as an anti-ſpaſmodic and ſedative medicine. It enters into the compoſition of the *pulvis temperans* of Stahl, which is prepared according to the Pharmacopeia of Paris, by accurately mixing three grains of ſulphat of potaſh, and of nitrat of potaſh, *vitriolated tartar and nitre,* with two ſcruples of artificial *cinnabar*. This compound is ſtill uſed, by expoſing the patients to its vapour. It then conſtitutes one of the methods of treatment of venereal diſorders by fumigation.

All the preparations of mercury, which are internally given, produce very beneficial effects in other diſorders, as well as thoſe of the venereal kind; ſuch as moſt diſorders of the ſkin, ſcrophulous diſorders, lymphatic ſwellings, &c. We cannot, however, forbear obſerving, that theſe medicines, more eſpecially the ſaline mercurial preparations, ought not to be applied but by experienced and cautious phyſicians; and that it is dangerous to the health, and even to the life of men, that mercurial remedies ſhould be in the hands of a great number of perſons, who, generally ſpeaking, are deficient, not only in the knowledge which is neceſſary to adminiſter them with ſucceſs, but even in that knowledge which might enable them to avoid danger. I have myſelf been more than once witneſs to the unhappy effects of theſe preparations, cauſed by the unſkilfulneſs of thoſe who have employed them with that raſhneſs which commonly accompanies ignorance. This ſubject appears to be of ſufficient importance to deſerve the attention of the legiſlature.

NOTES ON CHAPTER XV.

MERCURY.

[a] The ſpecific gravity of mercury, according to Briſſon, is 13,568; according to Muſchenbrock, 14,110.

[b] See *Braun Commentar. Petrop. Nov.* Tom. XI. p. 268, 302.

Hutchin's Phil. Tranſ. Vol. LXVI. p. 171. *Blagden Phil. Tranſ.* Vol. LXXVIII. p. 329.

From ſome experiments made on the congelation of mercury at the Polytechnic School in Paris, it appears that this ſubſtance, in paſſing from the ſolid to the fluid ſtate, abſorbs a quantity of caloric ſufficient to raiſe its temperature 187° of Fahrenheit's thermometer. See *Journ. de Polytech*, Tom. I. p. 123.

[c] At a heat it is ſaid of 600 deg. in Fahrenheit's ſcale.

[d] It has been propoſed to abridge this labour by uſing a glaſs veſſel, which has a neck about half an inch in width and four feet long, and of which the bottom part is not more than three or four inches in diameter. Half a pound of mercury having been introduced into this veſſel, and its mouth covered looſely with a bit of paper, ſo as not to exclude the external air, it is to be placed in a ſand bath, and an uninterrupted heat applied to it, ſufficient to raiſe the vapours of the mercury about two feet in the veſſel. This proceſs will be facilitated by removing from time to time the oxyd which is formed, and which covers the fluid mercury. See *Gren's Handbuck*, B. III. ſ. 188.

Van Mons has ſuggeſted a different method of preparing this ſubſtance. It conſiſts in rubbing equal parts of fluid mercury, and its red oxyd, with a little water in a ſtone mortar, till the mixture acquires a uniform black colour. This black powder, which is an imperfect oxyd of mercury, is to be expoſed in a broad open veſſel to a heat nearly approaching to a glow heat. During this expoſure it abſorbs quickly the baſe of oxygen gas from the atmoſphere, and is converted into a perfect oxyd. See *Gren's Journal de Phyſick*, B. VIII. ſ. 13.

[e] Lavoſier eſtimates this additional weight at ſeven three-fourths in the hundred.

[f] In a ſlow fire it is converted into the red oxyd of mercury.

[h] Fourcroy, in a memoir to be found in the Tenth Volume of the *Annalles de Chemie*, has deſcribed with great preciſion the different ſtates of the ſulphat of mercury. From his experiments it appears that very different compounds are formed according to the degree of oxydation of the mercury, the proportion of the mercury to the acid, the degree of temperature to which they are ſubjected, and the longer or ſhorter time they are expoſed to the heat.

If in heating an ounce of mercury with an ounce and an half of concentrated ſulphuric acid, the mixture be removed from the heat before it becomes dry, and while there is ſtill a portion of liquid remaining, the ſalt formed will contain the ſulphuric acid in exceſs, and will not afford turbith mineral by dilution with water. This ſalt Fourcroy terms the *acid ſulphat of mercury.* It becomes ſoluble in water in proportion to the quantity of acid which it contains. If waſhed with ſmall portions of this fluid, in a quantity leſs than that required to diſſolve it, the ſuperabundant acid is carried off, and the ſalt then forms a perfectly neutral compound, which Fourcroy terms ſimply *ſulphat of mercury.* This ſalt, which is of a very white colour, cryſtallizes in the form of thin priſms. Its ſtate is not very acrid. 500 parts of water at the uſual temperature of the atmoſphere, or 207 of boiling water, are required to diſſolve it. In its dry and cryſtalline form it contains, according to Fourcroy, 12 of ſulphuric acid, 75 of mercury, 8 of oxyen, and 5 of water. Cold and warm water diſſolve ſulphat of mercury, without producing in it any decompoſition. It is changed by the addition of ſulphuric acid to the ſtate of the acid ſulphat. By diſtillation ſulphat of mercury is reſolved into ſulphureous acid gas, oxygen, and fluid mercury. If this proceſs be ſtopped after the diſengagement of the ſulphureous acid gas, and before that of the oxygen gas commences, a yellowiſh maſs will be formed at the bottom of the retort, which immediately aſſumes a beautiful yellow colour on the affuſion of warm water. Cold water gives the yellow a ſlight tinge of green. Alcohol alſo gives a yellow colour to this maſs, but one leſs ſtrong than water. This yellow maſs, which is turbith mineral, Fourcroy terms *ſulphat of mercury with exceſs of oxyd.* In the common temperature of the atmoſphere, this ſalt diſſolves in 2000 parts of cold, and 600 of boiling water.

Yellow ſulphat, with exceſs of oxyd, diſſolves wholly in nitric acid. The ſolution contains nitrat of mercury and ſulphat of mercury; the quantity of the nitrat will vary, however, according to the degree of heat to which the ſulphat of mercury had been previouſly expoſed.

This ſalt is ſoluble alſo by heat in muriatic acid, and forms with it oxygenated muriat of mercury. If, inſtead of the yellow, the neutralized ſulphat be uſed, calomel or ordinary muriat of mercury is produced. Heated with fluid mercury the yellow ſulphat becomes of a black colour, and the globules of mercury diſappear in proportion as they rob the yellow ſulphat of the oxygen which it contains. The yellow ſulphat differs from the other two ſpecies in containing leſs acid, and a more highly oxydated mercury. 100 parts of it conſiſt, according to Fourcroy, of 10 of acid, 76 of mercury, 11 of oxygen, and 3 of water.

Potaſh, ſoda, and lime, precipitate the neutralized ſulphat of mercury of a dark grey, but the acid ſulphat of an orange colour. In the firſt caſe Fourcroy conceives that the mercurial oxyd parts with a portion of its oxygen, in the latter that it actually abſorbs an additional quantity.

Ammoniac precipitates ſulphat of mercury always of a grey colour, more or leſs deep, according to the ſtate of the mercurial ſulphat. The quantity of precipitate by this alkali is always leſs than when the fixed alkalis or lime are employed.

If a ſmall quantity of ammoniac be poured into a ſolution of neutralized ſulphat of mercury, a very copious grey precipitate is produced. This precipitate, expoſed on the filter to the rays of the ſun, is in part converted into fluid mercury, and the portion remaining is capable of being diſſolved in ammoniac. The precipitate therefore conſiſts of two ſubſtances, one a black oxyd of mercury, reducible by light, the other a triple ſalt, or ammoniaco-mercurial ſulphat.

If again the ammoniac be added in a large quantity, a much leſs copious precipitate is produced, but one which is much darker in its colour, and which is wholly reducible by expoſure to light. The ſupernatant liquor in this caſe contains a greater quantity of ammoniaco-mercurial ſulphat. During this action the ammoniac decompoſes only a part of the ſulphat of mercury. When it has ſaturated a portion of the ſulphuric acid, and ſeparated a part of the oxyd of mercury which it diſoxydates, the ſulphat of ammoniac unites with the undecompoſed mercurial ſulphat, and forms the triple ſalt, or the *ammoniaco-mercurial ſulphat.*

This triple ſalt, when perfectly neutralized, is not very ſoluble in water; but its ſolubility is greatly increaſed by an exceſs of the alkali. Ammoniac, in precipitating the oxyd of mercury, as has been remarked, takes from it a portion of its oxygen, by the loſs of which the mercury is reduced to the ſtate of the black oxyd. Fourcroy eſtabliſhed the reality of this action by the following experiment: Ammoniac was poured on ſulphat of mercury in its dry and ſolid ſtate; a lively effervescence, with a hiſſing noiſe, took place, and azotic gas was diſengaged; a very dark coloured powder was at the ſame time depoſited, reducible into liquid mercury by expoſure to light. The ſupernatant liquor contained ammoniaco-mercurial ſulphat. It ſeems ſuperfluous to remark, that in this proceſs water muſt have been formed by the combination of the hydrogen of the ammoniac with the oxygen of the mercury.

The ſolution of ammoniaco-mercurial ſulphat with ammoniac in exceſs, affords by ſlow evaporation very brilliant hard polygonal cryſtals, the form of which it is difficult to aſcertain from their minuteneſs. The cryſtals in this proceſs continue to be depoſited till the greater part of the ammoniac is volatilized. If, inſtead of allowing theſe cryſtals to form ſpontaneouſly, water in large quantity be added, a white powder is precipitated. The powder is a triple ſalt of the ſame nature with the cryſtallized. This effect ariſes from the greater affinity which the ammoniac has for the water than for the triple ſalt.

If the liquor, after the ſeparation of theſe cryſtals be ſlowly evaporated, ſulphat of ammoniac will be obtained. This ſhows clearly that the ammoniac, in decompoſing the ſulphat of mercury, forms a greater quantity of ſulphat of ammoniac than is required to change the undecompoſed mercurial ſulphat to the ſtate of a triple ſalt, or an ammoniaco-mercurial ſulphat. That the ammoniaco-mercurial ſulphat contains more ammoniac and oxyd of mercury than, if taken ſeparately, would have been required to ſaturate the ſulphuric acid, may be ſhown by mixing together ſaturated ſolutions of the ſulphats of mercury and of ammoniac. An ammoniaco-mercurial ſulphat is formed, and a quantity of free uncombined ſulphuric acid is contained in the liquor.

Ammoniaco-mercurial ſulphat is difficultly ſoluble in water, and has a ſharp, auſtere metallic taſte. The ſolution of this ſalt affords a white precipitate, with cauſtic fixed alkalis and lime. This precipitate, expoſed under water to the action of light, becomes of a black colour, gives out azotic gas, and is reduced to the ſtate of fluid mercury. Ammoniaco-mercurial ſulphat is reſolved by the fire into ammoniac, azotic gas, fluid mercury, and ſulphit of ammoniac, while the yellow ſulphat, or turbith mineral, remains behind in the retort.

Muriatic acid diſſolves this ſalt, and the ſolution contains oxygenated muriat of mercury, with the muriats and ſulphats of ammoniac. 100 grains of this ſalt conſiſt of 18 of acid, 23 of ammoniac, 39 of oxyd, and 10 of water.

It may be eaſily inferred from the foregoing facts, that when ammoniac is poured into the *acid ſulphat of mercury*, no precipitation will take place. The alkali ſaturates the acid in exceſs, and the ſulphat of ammoniac, which is formed, combines merely with the mercurial ſulphat to form the triple ſalt.

As the yellow ſulphat contains leſs of the acid, and more of the oxyd than the other two mercurial ſulphats, it forms with ammoniac a black oxyd reducible by light, and a much ſmaller quantity of the ammoniac or mercurial ſulphat.

[i] Fourcroy, in a memoir inſerted in the fourth volume of the *Annalles de Chemie*, has alſo ſhown, that the nitric ſolution of mercury exhibits phenomena with ammoniac, analogous to thoſe which are produced by the ſulphuric ſolution.

If ammoniac be added to the ſolution of the acid nitrat of mercury in a quantity not ſufficient to ſaturate the whole of the acid, the precipitates which falls down is of a white or ſlightly grey colour. If in a larger quantity, the greater part of the precipitate is rediſſolved, and what remains is of a dark grey or ſlate colour. When a ſtill larger quantity of ammoniac is ſuddenly added, no white precipitate is formed, but merely the black coloured grey precipitate in very ſmall quantity. If the liquor be now diluted with water, it becomes of a milky colour, and depoſits a white ſubſtance which does not become black by the addition of ammoniac. This precipitate has no ſmell. Its taſte is extremely ſharp and metallic, and it requires 1200 parts of water to diſſolve one of it in the ordinary temperature of the atmoſphere. Boiling water ſeparates from it a ſmall quantity of ammoniac, by which it becomes leſs ſoluble in that fluid. Lime alſo diſengages ammoniac from it. Muriatic acid diſſolves it readily; the ſulphuric diſengages from it a portion of nitrous gas. Lime, potaſh, and ſoda, occaſion the precipitation of a white powder in the watery ſolution of this ſubſtance. Diſtilled in a ſtrong heat, it gives out ammoniac, azotic gas, oxygen gas, liquid mercury, and, laſtly, a thin cruſt of yellow oxyd of mercury, which adheres to the upper part of the retort. Theſe facts are ſufficient to ſhow, that this precipitate is a triple ſalt, conſiſting of an oxyd of mercury, nitric acid, and ammoniac. According to Fourcroy, they are contained in it in the following proportion: 68 of mercury, 16 of ammoniac, and 16 of acid and water.

If the liquor from which this ammoniaco-mercurial nitrat has been precipitated be evaporated over a gentle fire till a ſlight ſaline pellicle forms on its ſurface, it depoſits by cooling ſmall priſmatic ſix-ſided cryſtals, which are terminated by pyramids. Theſe cryſtals conſiſt partly of nitrat of ammoniac, and partly of an ammoniaco-mercurial nitrat, the ſame in its nature, and in the proportion of its principles, with that which has been already deſcribed.

This black or ſlaty coloured precipitate is known in the ſhops by the name of the *pulvis mercurius cinereus*. Its colour and its other properties neceſſarily vary according to the quantity of ammoniac employed to form it. It is reducible by expoſure to light.

[k] This precipitate by ammoniac has been found by Fourcroy to be likewiſe a triple ſalt, or an ammoniacal muriat. 100 grains of oxygenated muriat of mercury afford, by the addition of ammoniac, 86 grains of a white pulverulent precipitate, which appears to be nearly inſoluble in water, though in the mouth it has a metallic taſte. Diſtilled in a retort, it gives out ammoniac both in the liquid and elaſtic ſtate, azotic gas, and mild muriat of mercury. It contains, according to Fourcroy, 81 of oxyd, 16 of acid, and 3 of ammoniac. The liquor from which this ſalt has been precipitated affords by evaporation muriat of ammoniac.

The addition of ſulphuric acid to ammoniaco-mercurial muriat forms a portion of oxygenated muriat of mercury, a portion of ſulphat of ammoniac, and a portion of ſulphat of mercury, ſo that an ammoniaco-mercurial ſulphit is eventually produced. The nitric acid produces changes in every reſpect ſimilar upon this ſalt; but as the ſulphuric or nitric acids can convert mild muriat of mercury into the oxygenated, only by giving to it a portion of their oxygen, it becomes eaſy to account for the production of the ſulphureous acid and nitrous gaſes, which takes place during the action of theſe acids on ammoniaco-mercurial muriat.

Muriatic acid diſſolves this ſalt completely, and renders it ſoluble in water.

Fourcroy ſuggeſts, that perhaps the metallic oxyds in theſe triple combinations perform the part of acids, and that in this new ſtate of combination they ſeem capable of forming neutral ſalts.

l The following proceſs deſcribed by Scheele for the preparation of the mild muriat of mercury, in the humid way, does not ſeem liable to any of the objections which Fourcroy ſtates to the preparation of this ſubſtance from the corroſive muriat.

Introduce equal parts of mercury and common aqua-fortis into a ſmall cucurbit with a long neck, and place this veſſel in the heat of a ſand bath. When the acid appears to act no longer on the mercury, the fire is to be augmented ſo as nearly to make the ſolution boil. This degree of heat is to be continued for three or four hours, and the veſſel now and then to be ſhaken. Towards the end the heat is to be regulated ſo, that the ſolution ſhall boil gently for a quarter of an hour. In the mean time, four ounces and a half of pure muriat of ſoda are to be diſſolved in ſix or eight ounces of water. Into this ſolution, heated to the boiling point, the ſolution of mercury is to be poured in ſmall quantities at a time, with conſtant agitation. When the muriat of mercury, which is formed, has ſubſided, the clear liquor is to be decanted off, and hot water poured on the precipitate, with which it is to be edulcorated till the water ſtanding upon it ſhall be entirely taſteleſs. It is then to be dried by a gentle heat.

By this proceſs, about eight ounces and a half of the mild muriat are commonly obtained from four and a half of the mercury.

m The oxyd of mercury combines with fluoric acid; part of the combination remains in ſolution in the acid, and part of it falls to the bottom in the form of a white powder. The fluat of mercury is decompoſed by muriatic and ſulphuric acids, and by earths and alkalis.

The phoſphoric acid has no action on mercury, but it combines readily with its oxyd. Phoſphat of mercury becomes ſoluble in water by an exceſs of acid. To form this ſalt, four ounces of pure phoſphoric acid diſſolved in water are to be boiled with three drachms of red oxyd of mercury in a porcelain diſh, till one half of the fluid is evaporated. The liquor is then to be filtered and evaporated to dryneſs. It may be formed alſo in the way of double affinity, by adding a ſolution of phoſphat of ſoda or ammoniac to a ſolution of the nitrat of mercury. The phoſphat of mercury formed in this way, containing no exceſs of acid, is very inſoluble in water.

Tartaric acid combines by boiling with the oxyd of mercury to form a difficultly ſoluble ſalt in ſmall ſhining ſcales. The acid of this ſalt is decompoſed by the fire, and the mercury reduced to the liquid ſtate. The tartaric acid takes mercury from a ſaturated ſolution of this metal in nitric acid. Tartarit of mercury is very conveniently formed, by adding a ſaturated nitric ſolution of mercury to a hot ſolution of tartarit of potaſh. Alkalis precipitate the mercury from this ſalt of a black colour. The tartaric is inferior in its affinity for mercury to the oxygenated muriatic, and ſulphuric acids.

Oxalic acid combines only with the oxyd of mercury. The oxalat is a white powdery ſubſtance, which becomes ſoluble in water by an exceſs of acid. It becomes blueiſh when expoſed to the light of the ſun. Oxalic acid takes mercury from the ſulphuric and nitric, but not from the muriatic acid. Its reſpective affinity with the phoſphoric has not been determined. This ſalt may be formed in the way of double affinity, by mixing the oxalat of an alkali with a ſaturated ſolution of nitrat of mercury.

The citric and malic acids diſſolve oxyd of mercury, but the ſalts which they form are little known.

Acetic acid, by digeſtion in the heat, diſſolves oxyd of mercury, and forms with it a white ſilver-coloured ſcaly ſalt, which is diſſolved with difficulty in warm, but more eaſily in boiling water. The taſte of acetat of mercury is moderately aſtringent, but ſomewhat ſharp. It is decompoſed by the addition of water, and a yellow oxyd precipitated. In a ſtrong heat the acid is diſſipated, and fluid mercury produced. This ſalt may be formed by adding acetat of potaſh to a ſaturated ſolution of mercury in the nitric acid. In affinity for mercury the acetic acid ſeems to be inferior to the muriatic, but ſuperior to the ſulphuric and nitric acids

Benzoic acid unites by boiling with the oxyd of mercury. The ſolution affords by evaporation a white powdery ſalt, which is difficultly ſoluble in water, and which affords a yellow precipitate with alkalis and lime water. Benzoat of mercury is volatile in the fire, and ſublimes into white radiated plumoſe cryſtals. It is moſt eaſily prepared, by adding benzoat of potaſh to a ſolution of mercury in the nitric acid. This ſalt is decompoſed by ſulphuric and muriatic acids.

The ſuccinic acid forms a difficultly ſoluble ſalt with the oxyd of mercury, the properties of which are but little known. Succinat of potaſh decompoſes the ſulphuric and nitric ſolutions of mercury.

The gallic acid precipitates mercury from all its ſolutions in acids. The precipitate from the oxygenated muriat is of a whitiſh yellow, that from the nitrat of a reddiſh yellow colour.

Pruſſiat of alkali precipitates mercury from its ſolutions in acids, at firſt of a whitiſh colour, but which becomes brown by drying. An exceſs of the pruſſiat rediſſolves the precipitate. Pruſſiat of mercury may be formed, according to Scheele, by boiling Pruſſian blue and red oxyd of mercury in water.

CHAPTER XVI.

CONCERNING TIN.

TIN, or *Jupiter* of the alchymiſts, is an imperfect metal, of a whiter and more brilliant colour than lead, but not quite ſo white as ſilver. It is eaſily bent, and produces a crackling noiſe when bent, a phenomenon which we have already obſerved, though leſs evidently, in zink, and which has been urged by Malouin, as an inſtance of ſimilarity between that metal and tin.

This noiſe appears to depend on the ſudden ſeparation of the parts of the metal, and ſeems to ſhow, that a fracture takes place, though tin reſiſts very little the effort which is made to bend it.

Tin is the lighteſt of all metals; it is ſufficiently ſoft to be ſcratched with the nail. In water it loſes about one ſeventh of its weight. It has evidently a ſmell, which becomes much ſtronger by heating or rubbing. It has likewiſe a peculiarly diſagreeable taſte, ſo ſtrong, that ſome phyſicians have ſuppoſed it to have a ſenſible action on the animal economy, and conſequently have recommended it in ſeveral diſorders. Its extreme ſoftneſs renders it ſcarcely at all ſonorous. Tin is the ſecond among metals in the order of ductility; it is reducible beneath the hammer into laminæ, thinner than leaves of paper, which are of great uſe in many arts. Its toughneſs is ſuch, that a wire of tin, of the tenth of an inch in diameter, ſupports a weight of forty-nine pounds and a half without breaking. The Abbé Mongez did not ſucceed in his attempts to cryſtallize tin; but De la Chenoye, one of my pupils, has ſucceeded, by fuſing the tin for a number of ſucceſſive times, by which means he obtained a rhomboidal aſſemblage of priſms or needles, united longitudinally to each other [a].

Moſt mineralogiſts ſtill doubt the exiſtence of native tin; ſome authors however affirm that it has been found in Saxony, in Bohemia, and in the peninſula of Malacca. It is ſtrongly affirmed, that it exiſts in the mines of Cornwall; and Sage has deſcribed a ſpecimen of this tin given him by Mr. Woulfe a chemiſt of London. This piece is grey and brilliant in its fracture; when beaten on the anvil, it forms brilliant and flexible laminæ. Tin is more commonly met with in a white ponderous opake oxyd, cryſtallized in octahedrons, or four ſided pyramids; its texture is lamellated and ſparry. Bucquet conſiders it as a true carbonat of tin. Sage thinks that theſe cryſtals are mineralized by the muriatic acid. It muſt be here remembered, that moſt of the cryſtals of white tin ore which are met with in collections, conſiſt of native tungſtat of lime, and that this ſalt muſt not be confounded with the oxyd of tin, which does not turn yellow by the contact of acids.

The appellation of tin ore is given more eſpecially to bodies of a very deep red, violet, or black colour, and of more conſiderable weight than any other mineral ſubſtance. Theſe ores are ſometimes cryſtallized in irregular cubes, and exhibit groups, diſperſed on a bed of quartz, or fuſible ſpar; they very frequently form maſſes, without any cryſtallization. Moſt naturaliſts agree in ſuppoſing the coloured ores of tin to be combinations of this metal with arſenic, and they attribute their exceſſive weight to the abſence of ſulphur. Sage and Kirwan think, however, that they do not contain any arſenic; and the former affirms, that it is not neceſſary to roaſt them, unleſs they be mixed with arſenical pyrites, which is a very common circumſtance. Kirwan affirms that the black tin ore contains $\frac{80}{100}$ of tin and iron. Bergman admits the exiſtence of ſulphurated tin in nature among the minerals of Siberia. This ſulphureous ore was externally of a golden colour, like aurum muſivum, and its internal part preſented a maſs of radiated cryſtals, white, brilliant, and brittle, and aſſuming changeable colours on expoſure to air. It contained a ſmall portion of copper.

There have been no mines of tin found in France. Baumé, however, ſuſpects, that it might be found in the neighbourhood of Alençon, and in ſome cantons of Britany, becauſe rock cryſtals are found, which appear to be coloured by that metal. The countries where they are the moſt abundant, and are worked, are the counties of Cornwall and Devonſhire, in England; Germany, Bohemia, Saxony, the Iſland of Banca, and the Peninſula of Malacca, the Eaſt Indies. Many naturaliſts have conſidered garnets as ores of tin, doubtleſs on account of their colour; they differ, however, from tin ores, by their tranſparency and their weight, which laſt is much leſs. Bucquet and Sage have not found that they contain tin.

The different ſtates of tin found in nature are not therefore numerous, and may be reduced to the following varieties.

Varieties.

1. Native tin in leaves or plates.
2. White ſpathoſe tin ore, in octahedral cryſtals.
3. Tin ore of a yellowiſh white; often coloured and ſemitranſparent, like topazes.
4. Brown or reddiſh tin ore, in priſms, with four right angled planes, terminated by quadrangular pyramids, the ſurfaces of which are iſoceles triangles. Theſe cryſtals are fixed into each other, or joined by one of their pyramids, ſo that externally only two ſmall triangular portions of two of the ſurfaces of this pyramid can be perceived, which form retreating angles, with the correſponding portions of the pyramid of the ſecond cryſtal. This union is in perfect analogy with its primitive form, which appears to be a dodecahedron with rhombic planes, but which has not yet been found iſolated.
5. Tin ſtone, *tinberg* of the Swedes; it is a ſtone or ſand which contains a mixture of oxyd of tin. The ſpecimens are grey, blue, brown and black.
6. Sulphureous ore of tin, of a brilliant colour ſimilar to that of zink, or golden, like *aurum muſivum*.

To make the aſſay of an ore of tin, it muſt be groſsly pounded, after dividing it into different parcels, waſhed and roaſted in a covered capſule of earth, care being taken to uncover it from time to time, in order to diſſipate the tin as little as poſſible; for if it be roaſted in an open fire much of that metal is loſt, as Cramer remarks. It muſt likewiſe be roaſted with expedition, leſt the tin ſhould be too much oxydated. Baumé, to obviate theſe two inconveniences, propoſes to mix a quantity of roſin or pitch, which reduces a portion of the oxyd formed in this operation. After the ore is roaſted, it is to be quickly fuſed in the crucible, with three parts of black flux, and a ſmall quantity of decrepitated marine ſalt. By comparing the weight of the waſhed and roaſted ore with that of the metallic button obtained, the quantity of foreign matter, and the proportion of tin it will afford in the hundred, is known. Cramer propoſes to make this aſſay in a more expeditious manner, and perhaps with leſs loſs, by making uſe of two large pieces of charcoal, one of them muſt have a cavity, to ſerve inſtead of a crucible, into which the ore is put, with a ſufficient quantity of pitch; the other is perforated with a ſmall opening, to give iſſue to the vapours. This is applied on the former to cover it, and they are tied together with iron wire, after having luted the joinings. Theſe are ſet on fire before the noozle of a pair of forge bellows, and kept there by means of charcoal placed round them. As ſoon as a ſufficient heat has been given to fuſe the tin, the charcoal is to be extinguiſhed with water, and the tin is found within them in the form of a button or globule.

Bergman propoſes to aſſay the ores of tin by ſolution in ſulphuric acid, to which the muriatic acid is afterwards added; and to precipitate it by fixed alkali. If the tin be pure, one hundred and thirty-one grains of the precipitate will be equal to one hundred and ſix of tin. If it be mixed with copper and iron, theſe foreign metals are to be removed by means of the nitric and muriatic acids.

The working of ores of tin in the large way is ſimilar to the proceſs before deſcribed; it is often neceſſary to make fires of wood in the mine, to calcine and ſoften the gangue, which is very hard, by which very dangerous vapours are diſengaged. This proceſs is uſed in the mines of Geyer. In other places the ores are found in ſand, at a very ſmall depth, as at Ebenſtock. The pounded ore is waxed in boxes, with little partitions of cloth, to retain the metallic particles; it is then roaſted in reverberatory furnaces, to which a horizontal chimney is adapted, to collect the ſulphur and arſenic; after which it is fuſed, and poured into moulds, to give it the form of blocks. The ores of tin are wrought nearly in the ſame way in Germany and in England. In the latter country this metal is alloyed with lead and copper, according to Geoffroy, and never exported in a ſtate of purity. We likewiſe receive from England a kind of tin in ſtalactites, which is called grain tin, which is thought to be very pure; but Bayen and Charlard affirm, that it ſometimes contains copper. The pureſt tin of all is that which comes from Malacca and Banca; the firſt has been run into moulds, which give it the form of a quadrangular truncated pyramid, with a narrow ſlope round its baſe; each ingot weighs about a pound. The ſecond is in oblong ingots, weighing forty-five or fifty pounds; theſe two kinds of tin are covered with a grey ruſt, more or leſs thick.

The tin which comes from England, and is much more uſed than the pure tin of the Indies, its price being lower, is in the form of large blocks, of about three hundred pounds weight. It is alloyed with copper, either artificially, according to Geoffroy, or naturally, according to Baron Dietrich. To facilitate the ſale, it is afterwards melted into ſmall ingots, or ſticks, of nine or ten lines in circumference, and about a foot and a half long.

Tin expoſed to heat in cloſe veſſels melts very quickly. It is the moſt fuſible of metals, and remains fixed as long as the fire is not raiſed; but this fixity appears to be only relative, ſince a conſiderable heat volatilizes it, as we ſhall ſhortly obſerve[b]. It is to be heated with acceſs of air; its ſurface becomes covered with a dull greyiſh pellicle, and aſſumes a ſhrivelled appearance. When this is taken away the tin is ſeen underneath with all its metallic brilliancy. A new pellicle ſoon becomes collected, and in this manner all the tin may be reduced into pellicles, which are nothing elſe but a metallic oxyd, or combination of the metal with the oxygen of the atmoſphere. Tin becomes one tenth heavier by oxydation. If the metal be heated to redneſs, Geoffroy has obſerved, that its oxyd is gradually raiſed by a very lively whitiſh flame, which he compares to that of zink. This is a true inflammation, or rapid combuſtion of the metal, at the ſame time that a light fume of tin is volatilized, which is condenſed on cold bodies into a whitiſh oxyd, in the form of needles. The grey oxyd of tin becomes white, if again expoſed to the action of a ſtrong fire; it unites to an additional quantity of oxygen, and becomes more oxydated. In this ſtate it is called *tin putty*. If it be expoſed to an exceedingly ſtrong heat, as for example that of a porcelain furnace, it melts into glaſs. Macquer and Baumé have obſerved, that tin thus treated in a crucible is converted into a white and needle-formed oxyd, and the part underneath is hard, coherent, reddiſh, and imperfectly melted; that another part forms a glaſs of the colour of a ruby or hyacinth; and that laſtly, at the bottom of the crucible a part of the tin remains in the metallic ſtate. Notwithſtanding this experiment the oxyd of tin is conſidered as infuſible, and it certainly requires a fire of the utmoſt violence to melt it into glaſs; the oxyd may be decompoſed by the addition of animal or vegetable combuſtible matters, which ſeize the oxygen contained in the oxyd, and cauſe the metal to re-appear with all its properties. It ſeems, however, that well oxydated tin-putty ſtrongly retains the baſe of the air to which it is united, ſince it is not reduced but with great difficulty, and by the addition of a large quantity of combuſtible matter. Hence it is that Baumé and other chemiſts have concluded, that when tin ores are too much roaſted there is a portion not reducible into metal.

Tin is not much altered by expoſure to air, and does not readily become tarniſhed when it is pure. The tin of commerce is covered, after a certain time, with a grey powder, which, according to Macquer, is merely ſuperficial, and never penetrates into the metal, as the iron does.

Water does not diſſolve or oxydate tin, though in proceſs of time it tarniſhes and appears to oxydate its ſurface.

Earthy matters contract no union with this metal. Its oxyd, which is very infuſible, does not form a tranſparent nor coloured glaſs with vitrifying ſubſtances; but as it is exceedingly white it renders the glaſs of a very opake white colour, by its interpoſition between the tranſparent parts. This kind of vitreous frit is called *enamel*. Putty of tin, on account of its infuſibility, deprives all glaſſes of their tranſparency, and converts them into coloured enamels.

The action of lime, magneſia, and alkalis on tin, has not been inquired into. It cannot, however, be doubted, but the latter ſalts, aided by the action of water, are capable of producing ſome change in the metal, ſince in a very ſhort time they cauſe it to exhibit the colours of the rainbow.

The concentrated ſulphuric acid, according to Kunckel, diſſolves half its weight of tin. The ſolution is performed very well by the aſſiſtance of heat. Sulphureous gas, of a very penetrating ſmell, is diſengaged, without any apparent effervescence or motion. The tin, in this experiment, ſeizes the oxygen of the ſulphuric acid, becomes quickly oxydated, and the acid is found to contain a ſufficient quantity of the oxyd to afford a precipitate by the addition of water. Sulphuric acid, diluted with a ſmall quantity of water, acts likewiſe on tin, but the ſolution is more permanent, and affords a leſs abundant precipitate on the addition of more water. Diluted, or feeble ſulphuric acid, does not diſſolve it. In this combination the tin ſeizes the oxygen of the ſulphuric acid, in ſuch quantities that ſulphur is very ſuddenly formed. This ſubſtance gives the ſolution a brown colour while it is warm, and is precipitated as ſoon as it becomes cold. Macquer and Baumé have aſcertained the preſence of ſulphur in this combination. When the ſolution is more ſtrongly heated, the tin is precipitated in the form of a white oxyd. The ſame phenomenon takes place without the aſſiſtance of heat, though in a much longer time.

Tin diſſolved in the ſulphuric acid is very cauſtic. Monnet, by cooling, obtained cryſtals ſimilar to calcareous ſulphat, or fine needles, intermixed with each other. The oxyd of tin precipitated from its ſolution by ſtanding, or by heat, is ſoluble in the ſulphuric acid. If the ſulphuric ſolution of tin be evaporated to dryneſs, the oxyd it affords is of a grey colour, very difficult of reduction, and no longer ſoluble in the acid. Alkalis precipitate tin from the ſulphuric acid, in the form of a very white oxyd.

Nitric acid is decompoſed by tin, even in the cold, with a ſingular degree of rapidity. This ſolution is one of the moſt ſtriking and rapid among chemical phenomena. It appears that the tin has a very ſtrong tendency to unite with the oxygen of the nitric acid; and as azote is far from adhering as ſtrongly to the oxygen in this acid as ſulphur to the ſame principle in the ſulphuric acid, it is not ſurpriſing that the decompoſition of the former by tin ſhould be much quicker than that of the latter by the ſame metal. Morveau has obſerved, that in a ſolution of tin by the nitric acid, no gas is diſengaged, but that ammoniac is formed. We ſee, therefore, that the tin not only decompoſes the nitric acid but likewiſe the water, ſince it can only be the hydrogen of the water, which, uniting to the azote of the nitric acid, forms the ammoniac produced in this operation. The tin is converted into a white oxyd, which Macquer in vain attempted to reduce. The metal in this ſtate appears to be ſuperſaturated with oxygen [c]. The nitric acid holds but a very ſmall quantity of the metal in ſolution; and when evaporated with the intention of obtaining cryſtals, the diſſolved portion quickly precipitates, and the acid remains nearly in a ſtate of purity. Bucquet however affirms, that a nitrat of tin, whoſe form he has not determined, may be obtained from this ſolution; it is very deliqueſcent. He likewiſe aſſerts, that if the oxyd of tin, produced by the decompoſition of the nitric acid, be waſhed with water, the fluid diſſolves a ſmall quantity of the nitrat of tin, which may be obtained by evaporation. The nitric acid retains a ſomewhat larger quantity of tin in ſolution, when it is uſed in a very diluted ſtate; but it lets it fall by ſtanding, or by the application of heat. Bayen and Charlard, in their valuable inquiries concerning tin, have diſcovered, that when the nitric acid is charged with all the tin it can oxydate, ſo as to become thick and incapable of acting on new portions of the metal, a *ſtanno-nitrous ſalt* is obtained by waſhing the maſs with a large quantity of diſtilled water, and evaporating the water to dryneſs, which ſalt detonates alone in a heated veſſel, and burns with a white and denſe flame, like that of phoſphorus. This ſalt is not a nitrat of tin, but a kind of triple ſalt or nitrat of ammoniac and tin. Diſtilled in a retort, it ſwells up, boils, and inſtantly fills the receiver with a white thick vapour of a nitrous ſmell.

The fuming muriatic acid acts ſtrongly on tin, and diſſolves it by the help of a gentle heat, and even in the cold, inſtantly loſing its colour and property of emitting fumes. The very ſlight efferveſcence which takes place in this combination diſengages a fetid inflammable gas from the mixture, not at all reſembling the ſmell of arſenic, as ſome chemiſts have affirmed [d]. The water is therefore decompoſed by the tin with the aſſiſtance of the acid. The muriatic acid diſſolves more than half its weight of tin; the ſolution is yellowiſh, of a very fetid ſmell, and does not afford a precipitate of oxyd of tin like the two laſt mentioned acids. By evaporation it affords brilliant and very regularly formed needles, which ſlightly attract the humidity of the air. Monnet affirms, that theſe needles, after having deliquiated, cryſtallize, and remain dry in the air. Baumé, who prepared the muriat of tin in the large way, as, for example, in the proportion of one hundred and fifty pounds of acid to twenty-five pounds of tin, for the manufacture of painted ſilks, has accurately deſcribed ſome of its properties. Out of twelve pounds of tin diſſolved in forty-eight pounds of muriatic acid, there remained two ounces ſix drachms of a grey powder, not ſoluble in one pound of the acid, with which he digeſted it for ſeveral days. Margraaf takes it to be arſenic, but Baumé did not examine it. He compares the ſmell of this concentrated ſolution to that of the black earths taken out of old ſewers, and remarks, that when it touches the fingers, nothing can take away the metallic ſmell peculiar to tin, which it communicates to them, and which is not diſſipated in leſs than twenty-four hours. He obſerves, that the cryſtals of the muriat of tin vary according to the ſtate of the acid. In ſome caſes they form ſmall white needles; and the ſame ſolution has afforded him white and roſe coloured cryſtals. The latter, purified by ſolution and evaporation, afforded, by cooling, large cryſtals, nearly ſimilar to thoſe of the ſulphat of ſoda. Another time, when the common muriatic acid was uſed, he obtained the ſalt in the form of ſmall ſcales, of a pearly white, ſimilar to that of boracic acid. He does not ſpeak of the action of fire on this ſalt. Monnet, who diſtilled the muriatic ſolution of tin, affirms that he obtained a fat matter, very fuſible, and afterwards a true *butter of tin*, with a fuming liquor ſimilar to that of Libavius, hereafter to be mentioned. This fact agrees with the obſervation made by Macquer on a ſolution of tin in the muriatic acid, which cryſtallized almoſt totally during the winter, and recovered its fluidity in ſummer; a property likewiſe obſervable in ſublimated muriat of tin. This illuſtrious chemiſt remarked, that a white depoſition ſubſided at the end of ſome years. The combination of the muriatic acid and oxyd of tin affords a much more abundant precipitate than other ſolutions, on the addition of alkalis and lime. Alkalis rediſſolve a part of the precipitated oxyd, and aſſume a yellow brown colour. It was by diſſolving a variety of ſpecimens of impure tin in this acid, that Bayen and Charlard ſucceeded in diſcovering a ſmall proportion of arſenic in the Engliſh tin. When this metal is contained in tin, the action of the acid produces a black colour in the metal, and when the ſolution is finiſhed, a blackiſh powder remains, which is arſenic, either pure, or united to a ſmall quantity of copper. This acid, therefore, may be uſed to diſcover the preſence and quantity of arſenic contained in tin [f].

The oxygenated muriatic acid diſſolves tin very readily, and without ſenſible effervеſcence, becauſe that metal quickly abſorbs the ſuperabundant oxygen from the acid, and does not require any decompoſition of the water to effect its oxydation. The ſolution has then all the characters of the preceding.

Nitro-muriatic acid, made with two parts of nitric acid, and one of muriatic acid, diſſolves tin with effervеſcence. A ſtrong heat is excited, which muſt be checked by plunging the mixture into cold water. To form a permanent ſolution of tin in this mixed acid, the metal muſt be added by ſmall portions at a time; one portion being ſuffered entirely to diſappear before a ſucceeding one be added; if the whole were added at once, great part of the metal would be oxydated. Aqua regia, by this management, will diſſolve half its weight of tin. The ſolution is of a reddiſh brown, nearly tranſparent, and frequently, in a few ſeconds, becomes converted into a tremulous jelly, of the appearance of reſin. This ſubſtance becomes more ſolid at the end of a few days, and may be cut in pieces like a firm animal jelly. Some parts exhibit the ſemi-tranſparency and whiteneſs of the opal. It emits a penetrating ſmell of muriatic acid, but is not fetid like the muriatic ſolution. I have preſerved it ſeveral years in a bottle, imperfectly cloſed, and found that it has not loſt any part of its ſolidity or tranſparency. In order that the ſolution of tin by *aqua regia* may form a jelly, it muſt be charged with a large proportion of metallic oxyd. Sometimes it becomes concrete, on the addition of half its weight of water, though it was perfectly fluid before: but the jelly formed by the addition of water is of an opal colour, becauſe, according to the remark of Macquer, the ſolution itſelf being decompoſable by water, a portion of the oxyd of tin is precipitated, and deſtroys the tranſparency of the jelly. This learned chemiſt has likewiſe obſerved, that if a ſolution of tin in nitro-muriatic be heated, an effervefcence is excited, which ariſes from the re-action of the mixed acid on the metal, its whole action not being already exhauſted. The ſolution then loſes all its colour, and becomes fixed by cooling. The jelly it forms in this caſe is beautifully tranſparent. Small needle-formed cryſtals are frequently depoſited from a liquid ſolution of tin by ſtanding. Neither theſe, nor the gas diſengaged during the action of nitro-muriatic acid on tin, have been yet examined. Bayen and Charlard find that this ſolvent might likewiſe be uſed to diſcover the preſence of arſenic in tin, if its action on this metal were leſs conſiderable. But this circumſtance prevents its indicating the quantity with the ſame preciſion as the muriatic acid.

The action of other acids on tin is not known [f].

All the neutral ſulphuric ſalts, and eſpecially the ſulphats of potaſh and ſoda, are decompoſed by tin. Equal parts of ſulphat of potaſh and tin being heated in a crucible, afforded me a greeniſh melted maſs, which no longer exhibited any metal, and was a true ſulphure of tin. The tin deprives the ſulphuric acid of its oxygen; the ſulphur diſengaged by this decompoſition combines with the potaſh, and this ſulphure diſſolves a portion of the oxyd of tin. It is the third metallic ſubſtance in which we have obſerved this property of decompoſing alkaline ſulphats. We ſhall preſently find that Glauber made the ſame obſervation on the ammoniacal ſulphat.

This metal cauſes nitre to detonate with rapidity. For this purpoſe it is melted, and made obſcurely red hot in a crucible. Dry nitre in powder being then thrown in, produces a white and brilliant flame. The tin, when the addition of nitre no longer produces detonation, is entirely oxydated. The white powder which remains contains alkali, rendered cauſtic by the oxyd of tin, and united to a certain quantity of that oxyd. By lixiviation, and the addition of an acid, the tin may be precipitated. The grey oxyd of tin is fuſible with nitre, becauſe, as Geoffroy has obſerved, it contains a portion of tin, which is only in a ſtate of extreme diviſion. If a perfect oxyd of this metal be taken, as for example, ſuch as has been long heated, and is very white; or inſtead thereof, ſuch an oxyd as is afforded by acids, the ſame phenomenon does not follow.

Tin very readily decompoſes ammoniacal muriat, and diſengages a very cauſtic and gaſeous ammoniac. Bucquet, who made a courſe of experiments on the decompoſition of ammoniacal muriat by metallic ſubſtances and their oxyds, obſerves, that much inflammable gas is diſengaged by the re-action of tin on the ammoniacal muriat. According to the experiments of this learned chemiſt, metals decompoſe this ſalt by virtue of the action of the muriatic acid on them: and as we have ſeen that the muriatic acid has a very ſtrong affinity with the tin, it may be concluded, that the theory of Bucquet is ſatisfactory, and perfectly conſonant with the facts. Glauber informs us, that his ſecret ſal ammoniac, or ſulphat, is decompoſed by tin; but this decompoſition is not complete, according to Pott, who repeated Glauber's experiment; doubtleſs becauſe the ſulphuric acid has not ſo ſtrong an affinity with tin as the muriatic. Bucquet likewiſe obſerves, that the tin being very fuſible, is collected in a button at the bottom of the retort, and that conſequently the ammoniacal muriat is not ſo completely decompoſed as otherwiſe it might be by the metal. For this reaſon tin does not decompoſe this ſalt as perfectly as leſs fuſible metals. The reſidue of the decompoſition is a ſolid muriat of tin, decompoſable by water, and ſimilar to that which is formed by this metal with corroſive muriat of mercury, hereafter to be treated of.

Tin may be eaſily combined with ſulphur, by throwing one or two parts of ſulphur in powder, on five or ſix parts of tin melted in an iron ladle. The mixture being agitated with an iron ſpatula, becomes black, and takes fire. If it be melted in a crucible, a brittle maſs, diſpoſed in flat needles united together, is obtained. This compoſition is much more difficult to melt than tin, a property common to all combinations of ſoft and fuſible metals with ſulphur. But the moſt important circumſtance is, that though tin eaſily unites with ſulphur by fuſion, it is very ſeldom found naturally in this ſtate. The fact is abſolutely the contrary with zink, which is frequently combined with ſulphur in its ores, though it does not unite with it in our laboratories without the greateſt difficulty. The operations of nature are often very different from thoſe of art; but though ſome natural combinations are found, which art has not ſucceeded in imitating, it is likewiſe certain, that many compoſitions are artificially produced, of which nature furniſhes no model[g].

Arſenic ſcarce unites with tin by fuſion, becauſe the greater part is diſſipated. The arſeniat of potaſh combines better with that metal; and Baumé has obſerved, that in this combination, the arſenic acid quitting the alkali to unite with the tin, to which it yields a portion of its oxygen, produces a brittle brilliant button, diſpoſed in facets like antimony. The experiments which Margraaf has made concerning the union of tin with oxyd of arſenic, by diſtillation, have ſhown us, that part of this oxyd is reduced into arſenic, while a portion of the tin is oxydated. The tin thus united to arſenic, is not ſeparable by the action of the moſt violent fire, and it is probable the former metal always retains a portion of arſenic, ſufficient to render its uſe dangerous in culinary operations. When the oxyd of tin, charged with arſenic, is expoſed to diſtillation, a ſmall quantity of liquid, which has the ſmell of phoſphorus, is obtained, according to Margraaf. Bayen and Charlard have, ſince his time, examined the combination of arſenic and tin. They obſerve, that the oxyd of arſenic, called ſimply *white arſenic*, does not combine with tin, but in proportion as it acquires the metallic ſtate; and that this combination is effected much better, by directly uniting the *regulus* of arſenic with tin. If three ounces ſix drachms of tin be put into a retort, with two drachms of *regulus* of arſenic in coarſe powder, and the retort, after adapting a receiver, be heated to redneſs, ſcarcely two grains of arſenic are elevated in the neck of the veſſel, and a metallic button, weighing four ounces, is found at the bottom of the retort. This alloy, which contains one ſixteenth of its weight of arſenic, is cryſtallized in large facets, like biſmuth. It is more brittle than zink, and leſs fuſible than tin. It firſt becomes ſoft by heat, and if in this ſtate it be touched with an iron rod, a crackling noiſe is produced by the friction of its laminæ on each other. It melts into the conſiſtence of paſte, and gradually emits arſenic in the form of fumes.

Cobalt unites by fuſion to tin, and forms an alloy in ſmall cloſe grains, of a light violet colour.

Tin and biſmuth afford, according to Gellert, a brittle alloy, preſenting cubic facets in its fracture. Tin is ſometimes alloyed with this metal, to give it whiteneſs and hardneſs. As it communicates a great degree of firmneſs, and is dearer than zink, which produces the ſame effects on tin, workmen cannot be ſuppoſed to employ it in a larger proportion than a pound, or a pound and a half in the hundred, in which caſe, its effects on the animal economy need not be feared. But in larger proportions they might be ſuſpected to reſemble thoſe of lead, from the ſtrong affinity between the properties of biſmuth and that metal. Biſmuth may be ſeparated from tin by the muriatic acid, which diſſolves the latter, and ſuffers the former to precipitate in a black powder, provided the acid be weak. Nitro-muriatic acid, diluted with water, produces the ſame effect.

Antimony, united to this metal, affords, according to Gellert, a white and very brittle metal, whoſe ſpecific gravity is leſs than that of the two metallic ſubſtances taken ſeparately.

Zink unites perfectly with tin, and produces a hard metal of a cloſe grained fracture, and more ductile in proportion as the quantity of tin is larger.

Cronſtedt affirms, that nickel united to tin forms a white and brilliant maſs, which, when calcined under a muffle, riſes in the form of a vegetation.

Mercury diſſolves tin with great facilty, and in all proportions. To make this combination, heated mercury is poured on melted tin; the amalgam produced, differs in its ſolidity according to the relative doſes of theſe two metallic ſubſtances. An amalgam was formerly made with four parts of tin, and one of mercury, which were caſt into balls that became ſolid in cooling; theſe balls were ſuſpended in water for the purpoſe of purifying it: but as the water was at the ſame time made to boil, the precipitation of foreign ſubſtances, which contaminated the water, was entirely owing to the laſt circumſtance, and not to the metallic ſubſtance. The amalgam of tin is capable of cryſtallizing, and has the form of ſmall cubes, as Daubenton obſerved in the amalgam of tin uſed by him to cloſe the mouths of veſſels containing preparations in the King's garden. Sage affirms, that the cryſtals are grey, brilliant, and in plated laminæ, thin towards their edges, and that the cavities between them are polygonal.

Tin has a ſtronger affinity with oxygen than mercury, and decompoſes the corroſive mercurial muriat. To effect this, the tin is firſt divided by the addition of a ſmall portion of mercury; equal parts of this amalgam, and the corroſive mercurial muriat, are triturated together, and the mixture expoſed to diſtillation in a glaſs retort, by a very gentle heat. A colourleſs liquor firſt paſſes over, and is followed by a thick white vapour, which iſſues with a kind of exploſion, and covers the internal ſurface of the receiver with a very thin cruſt. The vapour becomes condenſed into a tranſparent liquor, which continually emits a thick, white, and very abundant fume. It is called the *fuming liquor of Libavius*, and is the combination of the muriatic acid and tin, the acid appearing to be ſuperſaturated with oxygen. This liquor, when cloſed in a bottle, does not emit viſible vapours, though a certain quantity is diſengaged, which depoſits the oxyd of tin in needle-formed cryſtals, at the upper part of the bottle; ſo that the extremity of the neck becomes accurately cloſed at the end of ſome months. A ſmall portion of this oxyd is likewiſe precipitated to the bottom of the liquor, in the form of regular ſcales. The ſmell of this fluid, which is very penetrating, excites coughing: the vapours are not viſible without contact of air, and ſeem to conſiſt of a peculiar gas, decompoſable by air, which in that caſe depoſits the oxyd of tin, in the ſame manner as the fluoric acid gas depoſits ſiliceous earth by the contact of water, and as the ſulphurated hydrogen gas depoſits ſulphur by the contact of air. May not this elaſtic fluid be a combination of the oxygenated muriatic acid gas and oxyd of tin?

Water does not ſenſibly precipitate the *fuming liquor of Libavius*, but ſeems to effect a decompoſition which has not yet been examined. When this liquor, newly prepared, is poured into diſtilled water, it occaſions a ſlight noiſe, reſembling that of ſulphuric acid, during its union with the ſame fluid. It appears to ſeparate a great number of ſmall tranſparent particles, of an irregular figure, which do not ſeem to have any affinity with water. On a cloſer attention to the mixture, each of theſe particles is obſerved to emit a bubble, which breaks at the ſurface of the water, and emits a vapour, which becomes white by the contact of air. On agitating the water, theſe particles are very quickly diſſolved, and the ſolution no longer emits vapours. Macquer affirms, that when the fuming liquor is diluted with a large quantity of water, it precipitates the oxyd of tin in ſmall white flocks. The gas of the fuming liquor is not very elaſtic, as it never cauſes the ſtopper of the bottle in which it is cloſed to fly out, as happens occaſionally to the nitric and muriatic acids, ammoniac, ether, &c. Adet, who read a memoir to the Academy upon *the fuming liquor of Libavius*, has ſhown, (1.) That the effervescence, which takes place as often as it is mixed with water, depends on the diſengagement of an elaſtic fluid, which poſſeſſes all the properties of azotic gas: (2.) That the fuming liquor, combined with water, in the proportion of 7 to 22, forms a ſolid body, which melts by the action of heat, congeals by cold, and reſembles the oxygenated muriat of tin, or *butter of tin:* (3.) That the fuming liquor, diluted with water, diſſolves tin without the diſengagement of hydrogen gas, and affords a ſalt ſimilar to that which is obtained by the direct combination of the muriatic acid and tin. He concludes, from his various experiments, that the fuming liquor is nothing elſe but a compound of the muriatic acid in the aeriform ſtate, and the oxyd of tin in which oxygen predominates; and that this ſalt is the ſame, with reſpect to the common muriat of tin, as the oxygenated muriat of mercury is to the muriat of mercury, or *mercurius dulcis* [h].

The reſidue of the diſtillation of the *fuming liquor of Libavius*, exhibits phenomena equally intereſting with thoſe of the liquor itſelf. The upper part and the neck of the retort are covered with a light, white, and greyiſh cruſt, which, according to the experiments of Rouelle the younger, contains a ſmall quantity of the fuming liquor, concrete muriat of tin, or corneous tin, mercurial muriat, and running mercury: the bottom of the veſſel contains an amalgam of mercury and tin, above which is a *corneous tin* of a light grey, ſolid and compact, which may be volatilized by a ſtronger heat. If this ſubſtance be put into a retort, it melts, and is ſeparated into two diſtinct ſubſtances, the one black, and lying beneath the other, which is white, and reſembles *corneous tin.* Rouelle appears to ſuſpect that theſe two ſubſtances, which differ from each other, and do not mix, ariſe from the tin being alloyed with ſome other metal; the more the tin is alloyed, the ſmaller the quantity of *fuming liquor* it affords, according to this ſkilful chemiſt. Solid muriat of tin attracts the moiſture of the air, and is eaſily ſoluble in water, which diſtinguiſhes it from corneous lead. Baumé has publiſhed a theory reſpecting the combination of tin with the muriatic acid, which nearly reſembles that of Scheele and Bergman, concerning that which they have called *the dephlogiſticated marine acid.* He thinks that this acid loſes its *phlogiſton* in the operation, as thoſe chemiſts ſuppoſed likewiſe to happen in the diſtillation with oxyd of mangaueſe. He ſuſpects that this acid would be obtained perfectly pure, by diſtilling the *fuming liquor of Libavius.* Whence it appears that he regards the common muriatic acid as ſurcharged with *phlogiſton.* Baumé has, therefore, from this obſervation, the precedence in point of time over Scheele for the diſcovery of the two ſtates of the muriatic acid; but he has not deſcribed the ſingular properties of this oxygenated acid, as the celebrated Swediſh chemiſt has done.

The uſes of tin are very numerous. It is applied to many purpoſes in the arts, in forming many veſſels, organ pipes, decorations, &c. Its amalgam is applied to ſilver looking-glaſſes. Copperſmiths pour a mixture of tin and lead on copper veſſels, in the operation called tinning. Bell metal, and bronze for ſtatues, are compounds of this metal, with copper. The pewterers mix tin with biſmuth, antimony, lead and copper, to make utenſils of all ſorts, which are very ſubject to change by expoſure to air. Putty tin is uſed in poliſhing many hard bodies. Tin is melted with oxyd of lead and ſand, to make enamel, as well as to glaze pottery, &c. The cryſtallized muriat of tin is uſeful in the art of calicoe printing. Its ſolution in *aqua regia,* or nitro-muriatic acid, heightens the tincture of cochineal, of gum lac, &c. ſo as to convert it into the moſt lively fire colour. The dyers make uſe of this ſolution, which they call compoſition, to make ſcarlet. When it is mixed in the dyers bath, it forms a precipitate, which carries down the colouring matter, and depoſits it on the ſtuff which is to be dyed. This obſervation is due to Macquer, whoſe labours have greatly improved this art.

The uſe of tin in culinary operations has been eſteemed very dangerous by ſome chemiſts. Navier, in his treatiſe on Counter Poiſons, &c. affirms, that ragouts, in which tin ſpoons have been left, as well as ſugar contained in a veſſel of this metal, have poiſoned many perſons. Theſe unhappy effects have been almoſt generally attributed to the arſenic which Geoffroy, in the year 1738, affirmed to exiſt in tin, and which Margraaf imagined he had found in the pureſt tin, even in a very conſiderable proportion.

But the fears which have been excited on this ſubject are diſſipated by the experiments of Bayen and Charlard, whom we have had already occaſion to quote, in the hiſtory of this metal. Theſe chemiſts proved, by the moſt deciſive experiments, 1. That the quantity of arſenic, extracted by Margraaf, from the tin of Morlaix, and which is near thirty-ſix grains per half ounce, would be much more than ſufficient to deprive this metal of all the ſoftneſs and flexibility it is known to poſſeſs, and would render it as brittle as zink. 2. That the tin of Banca, and of Malacca, does not contain an atom of this dangerous ſemi-metal. 3. That Engliſh tin, in large blocks, affords, by the action of muriatic acid, a ſmall quantity of blackiſh powder, often mixed with copper and arſenic, in which the latter never exceeds three quarters of a grain in the ounce of tin, and is often leſs than that quantity. 4. That the mixture made by the pewterers, of the Engliſh block tin, with the pure tin of Malacca, or Banca, diminiſhes this doſe ſtill more. 5. That arſenic, united with tin, loſes a part of its properties, and its corroſive action. 6. Laſtly, That the ſmall quantity of tin thus alloyed, which may enter into food by the daily uſe of veſſels made of this metal, is not ſufficient to produce any effect on the animal economy, ſince, according to a calculation made on the loſs a tin plate ſuffered during two years wear, the quantity ſwallowed at moſt does not amount to three grains in the month, and conſequently the 5760th part of a grain of arſenic per day, ſuppoſing that tin wrought at

Paris contained as much of this poiſonous ſemi-metal as the plate or diſh made in London, on which Bayen made his experiments.

We will here obſerve, that the diſagreement between the Pariſian chemiſts and Margraaf, may ariſe from the latter having made his experiments on Saxon tin, and the former on the tin uſed in France, which comes from the Eaſt Indies and from England.

We may alſo obſerve, that many phyſicians, who have directed their attention to metallic ſubſtances, conſidered as medicines, have already acknowledged the innocence of this metal, and have even adviſed its filings to be taken in ſubſtance in diſorders of the liver, of the matrix, and for worms. Schulz, in his diſſertation on the uſe of Metallic Veſſels, in the preparation of food and medicines, recommends pure tin as very wholeſome. La Poterie preſcribes oxyd of tin as one of the component parts of a preparation called antihectic, which conſiſts of oxyds of antimony and tin, formed by detonation with nitre; the alkali, which the water diſſolves, always retains a portion of the metallic oxyd.

Tin is recommended as a vermifuge. I have been informed that it has been employed in large doſes at Edinburgh without effect. Some country people are in the habit of infuſing ſweet wine for four hours in the cold, in a tin veſſel, and giving a glaſs of this liquor to their children who are troubled with worms. Navier was a witneſs to a girl of ſixteen or ſeventeen years old, who voided downwards thirty of the worms called *teres*, with plentiful ſtools, ſome hours after having taken a liquid of this kind; the medicine therefore acts as a violent purgative.

NOTES ON CHAPTER XVI.

TIN.

a The ſpecific gravity of tin, according to Bergman, is, 7264.

b It melts at a heat of about 420°.

c The quantity of oxygen in the oxyds of tin, from ſolution in the nitric acid, differs according to the ſtate of the acid, the proportion of the tin, and the degree of temperature in which the ſolution is made. Prouſt affirms, that the oxyd obtained in a low temperature, and in a diluted acid, contains only 30 per cent of oxygen, while that from concentrated acid with heat contains no leſs than 40 per cent. of that ſubſtance. The former decompoſes the oxygenated muriat of mercury, and is inſoluble in muriatic acid; not ſo the latter. See *Annal. de Chem.* Tom. XXVIII. p 218.

d Prouſt, however, affirms, that if this gas be burned under a glaſs veſſel, the arſenic will be depoſited on its ſides. Tom. XXIV. p. 127.

e Pelletier prepared the muriat of tin, by introducing into a matraſs four parts of concentrated muriatic acid with one of tin cut into very ſmall pieces. The matraſs was placed on a ſand bath, and the tin wholly diſſolved by the aſſiſtance of a boiling heat.

When oxygenated muriatic acid gas is introduced into this ſolution, the gas is abſorbed, caloric evolved, and an oxygenated muriat of tin formed, which may be obtained in a cryſtalline form by evaporating the ſolution.

When nitric acid is added to a ſolution of muriat of tin, an immediate diſengagement of nitrous gas takes place, and the muriat is changed into the oxygenated muriat.

Muriat of tin has no action on ſulphuric, but it decompoſes the ſulphureous acid, by taking from it the oxygen which it contains. The diſengaged ſulphur attracts to itſelf a portion of the oxyd of tin, which quits the acid, and forms with the ſulphur a yellow ſulphurated oxyd.

The arſenic acid and its oxyd yield their oxygen to muriat of tin, and are by this reduced to the metallic ſtate. Muriat of tin produces the ſame effects on the molybdic and tungſtic acids.

If red oxyd of mercury be added to a ſolution of muriat of tin, it is immediately decompoſed, and the mercury appears at the bottom of the veſſel in the ſtate of fluid mercury.

The addition of oxyd of mangaueſe to this ſolution occaſions an evolution of caloric and the production of the oxygenated muriat. Similar effects are produced by the oxyds of antimony, zink, and ſilver.

If oxygenated muriat of potaſh be added to a ſolution of muriat of tin, the mixture becomes warm, aſſumes a greeniſh yellow colour, and oxygenated muriatic acid gas is diſengaged.

Oxygen unites directly with the ſolution of muriat of tin, and forms with it the oxygenated muriat. Pelletier confined about ſix cubic inches of oxygen gas in a proper apparatus over muriat of tin, and found that in leſs than twenty hours the whole of the oxygen gas had been abſorbed. *Ann. de Chem.* Tom. XII. p. 225.

[f] Fluoric acid diſſolves the oxyds of tin, and forms with it a gelatinous maſs, the properties of which are but little known.

The boracic acid diſſolves tin by boiling in water, and ſhoots with it into ſmall irregular granular cryſtals. In the fire this ſalt melts into an opake grey ſlag.

Phoſphoric acid combines by the aſſiſtance of heat with tin, and forms with it a ſalt difficultly ſoluble in water. Phoſphat of tin is eaſily changed into a glaſs-like ſubſtance in the fire. Phoſphoric acid precipitates tin from its ſolution in aqua regia; but the affinity of this compared with the other acids is not known.

Pure tartaric acid has no perceptible action on tin; but a ſolution of tartarit of potaſh boiled with water and tin diſſolves a conſiderable quantity of this metal, and forms with it an eaſily ſoluble, permanent, needle-ſhaped ſalt.

Tin diſſolved by heat in oxalic acid at firſt becomes black, and is afterwards covered with a grey powder. An elaſtic fluid is diſengaged, which does not appear to have been examined. The ſolution has an auſtere taſte, and affords by evaporation, priſmatic cryſtals. By quick evaporation a horny-like maſs is formed, which gives a copious precipitate with alkalis. Oxyd of tin diſſolves eaſily in oxalic acid. The oxalat of tin has always an exceſs of acid, and is difficultly ſoluble in water.

Acetic acid diſſolves tin only in a ſmall quantity. The ſolution, which has a metallic taſte, ſoon becomes muddy, and depoſits a white oxyd. This combination does not cryſtallize. The oxyd of tin diſſolves readily in acetic acid. If ſpirit of wine be added to this ſolution after it has been evaporated to the conſiſtence of a ſyrup, cryſtals of acetat of tin are obtained, which are hard, heavy, white, tranſparent, and taſteleſs. This ſalt is decompoſed by the ſulphuric, muriatic, and nitric acids, and by fire.

The citrat and malat of tin are unknown.

The benzoic acid, according to Trommſdorff, acts directly neither on tin nor its oxyd; but benzoat of potaſh is ſaid to decompoſe the muriat of tin, and to form with the tin a ſalt difficultly ſoluble even in boiling water.

Pruſſiat of potaſh precipitates tin white from its ſolution in muriatic acid. The precipitate by the gallic acid is of a white grey colour. See *Gren's Handbuch. Zinn.*

[g] Many curious facts reſpecting the formation and properties of this combination are detailed by Pelletier in a memoir inſerted in the 13th volume of the *Annales de Chemie.* The proportion of the ſulphur in the combination deſcribed by Fourcroy does not exceed 20 per cent.; but by a particular management, and by the uſe of different intermedia, the ſulphur may be combined in a much larger proportion, forming the golden-coloured ſubſtance commonly known by the name of *Aurum Moſaicum*, or *muſive gold.*

For the preparation of this ſubſtance, Woulff had recommended the following proceſs: Twelve parts of tin are to be melted in a crucible by a briſk fire, and three parts of mercury added to it; this maſs is to be reduced to a powder in a ſtone mortar; it is then to be intimately mixed by rubbing it with ſeven parts of ſulphur, and three of muriat of ammoniac. The mixture which theſe form is to be introduced into a glaſs matraſs, of which it fills nearly one half, and the matraſs placed in a ſand bath, and expoſed to a ſtrong fire ſo long as any white vapours continue to be diſengaged. On removing the mixture from the heat, *muſive gold* will now be found at the bottom of the matraſs; but if the heat be continued or increaſed, the *muſive gold* will loſe its colour, and be converted into an ordinary ſulphure of tin. See *Phil. Tranſ.* Vol. LXI. p. 114

A variation in the proportion of theſe ingredients produces no very eſſential change in the reſults. Pelletier obtained a very beautiful *muſive gold* by diſtilling together equal parts of mercury, muriat of ammoniac, tin, and ſulphur. The explanation which this chemiſt gives of the different changes which occur in this complicated proceſs is ſo extremely happy, that I think I cannot do better than place the whole of it immediately under the eye of the reader. "The previous rubbing with the mercury helps to oxydate the tin. A diſengagement of hydrogen gas is produced by the re-action of the muriat of ammoniac on the tin. The oxyd of tin which is formed decompoſes the muriat of ammoniac, and the diſengaged ammoniac uniting with the ſulphur, paſſes over into the receiver in the form of an ammoniacal ſulphure. The muriatic acid unites with the oxyd of tin, and forms with it muriat of tin, a very ſmall portion of which paſſes over in diſtillation; the other portion is afterwards decompoſed by the action of the fire, while the oxyd of tin which remains unites with the ſulphur to form the *muſive gold.* The muriatic acid, which is volatilized, meeting with the ammoniac, combines with it, and reproduces muriat of ammoniac. In this proceſs there is a portion of tin which has been ſimply oxydated, and which in this ſtate unites with the ſulphur to form *muſive gold.* There is alſo a portion of muriat of ammoniac which eſcapes decompoſition, and which of courſe is ſublimed. The mercury combines with the ſulphur, and forms with it the ſulphure of mercury, which paſſes over during diſtillation. A ſmall portion of *muſive gold,* in beautiful plates, is ſometimes found in the upper part of the veſſel in which the ſublimation is performed. The muriat of ammoniac, in being volatilized, carries along with it a ſmall portion of the oxyd of tin; and it is this portion of oxyd which in the moment of volatilization unites to the ſulphur it meets with in a ſtate of vapour, and forms with it the *muſive gold* that is attached to the upper part of the veſſel. It is very neceſſary in this proceſs to be cautious in the management of the fire, for if this be raiſed too high, ſulphureous acid gas will paſs over towards the end of the operation, and, inſtead of *muſive gold,* a black coloured metallic ſubſtance, or common ſulphure of tin, will be obtained." The different parts of this explanation will be fully illuſtrated by the following experiments.

Six hundred grains of ſulphur being added to a ſolution of 600 grains of tin in 4 ounces of muriatic acid, and evaporated by a gentle heat, a concrete ſubſtance was obtained. During the evaporation, copious vapours of muriatic acid were diſengaged. This concrete ſubſtance being reduced to a powder, was put into a retort, and expoſed to a ſtrong heat. Concrete muriat of tin, and afterwards a little ſulphur, were ſublimed into the neck of the retort. The reſidue was *muſive gold,* of a beautiful colour.

A mixture of equal parts of tin filings, ſulphur, and muriat of ammoniac, afford by diſtillation a ſulphure of ammoniac, ſulphurated hydrogen gas, a little ſulphur, and muriat of ammoniac. In this proceſs, the muriat of ammoniac is decompoſed by the tin, and the diſengaged ammoniac unites with the ſulphur, and forms the ſulphure of ammoniac. The muriatic acid unites with the tin, and diſengages the hydrogen gas, which, in being volatilized, carries along with it a ſmall portion of ſulphur, and forms with it the ſulphurated hydrogen gas. The muriat of tin is afterwards decompoſed by the fire: the diſengaged acid finding again the ammoniac, reproduces the muriat of ammoniac, while the oxyd of tin remaining fixed, unites with the ſulphur to form *muſive gold.*

The frequent failure which artiſts experience in the proceſs for making *muſive gold,* appearing to Pelletier to depend on the too great degree of heat which they employ, he was induced to try the following experiment:

Sulphur was added in different portions to 100 ounces of melted tin, till the tin appeared to be ſaturated with it. By each addition, the metal ſeemed to become leſs fuſible. When cooled, the maſs weighed 116 ounces and a half. Equal parts of this maſs reduced to powder, and muriat of ammoniac, were diſtilled together in a heated retort. A ſmall portion of ammoniac was diſengaged, ſome drops of ſulphure of ammoniac came over, and laſtly, muriat of ammoniac was ſublimed into the neck of the retort. The reſidue was a black irideſcent maſs, reſembling ſome ſpecies of pyrites.

To the ingredients of the former mixture, an equal portion of ſulphur was added, and the whole ſubjected to diſtillation. The products were, ſulphurated hydrogen gas, ſulphat of ammoniac, a little ſulphur, and muriat of ammoniac having a yellow colour. The reſidue was *muſive gold*. In this experiment, the ammoniac diſengaged from the muriatic acid finds a portion of uncombined ſulphur with which it unites, and forms the ſulphure of ammoniac. The oxyd and muriat of tin which are formed alſo uncombined, find ſulphur; ſo that the oxyd of tin is eventually fully ſaturated with ſulphur.

Three ounces of ſulphure of tin were diſtilled with three ounces of the oxygenated muriat of mercury. White vapours were diſengaged, muriat of tin was ſublimed into the neck of the retort, and fluid mercury paſſed over into the receiver. The reſidue, a very beautiful *muſive gold*, weighed 2 ounces and a half. Muriat of tin, in this proceſs, was volatilized, becauſe the quantity of ſulphur contained in the ſulphure of tin was not ſufficient to ſaturate the whole of the oxyd which had been produced. Perhaps, by diminiſhing the quantity of oxygenated muriat of mercury, or by adding a little more of the ſulphur, it may be poſſible to prevent altogether the loſs which ariſes from the volatilization of the muriat of tin.

A mixture of equal parts of ſulphure of tin and red oxyd of mercury, by the nitric acid, were diſtilled together. Fluid mercury came over into the receiver, and the reſidue conſiſted of a mixture of *muſive gold* and undecompoſed ſulphure of tin.

Six hundred grains of ſulphure of tin were diſtilled with 600 grains of cinnabar, or the ſulphurated oxyd of mercury. Fluid mercury paſſed over into the receiver; the reſidue in the retort was *muſive gold*. In this proceſs, the oxygen of the mercury united with the tin to form the oxyd of tin, while this retained not only the ſulphur with which it was formerly combined, but alſo that which had been imparted to it by the ſulphure of mercury. But as ſulphure of mercury contains 20 per cent. of ſulphur, and ſulphure of tin from 15 to 20, *muſive gold* muſt neceſſarily contain from 35 to 40 per cent. of that ſubſtance.

Equal parts of ſulphur and oxyd of tin, precipitated from its ſolution in muriatic acid, were diſtilled together. Sulphureous acid gas was diſengaged, and ſome ſulphur ſublimed into the neck of the retort. The reſidue was *muſive gold*.

Similar productions were obtained with an oxyd of tin from the nitric acid.

Sulphat of ammoniac was added to a ſolution of tin in muriatic acid. A reddiſh precipitate was formed, which aſſumed a black colour by drying it. Diſtilled in a gentle heat, this precipitate gave out a little ammoniac; the reſidue was *muſive gold*. In this proceſs, the muriatic acid quits the oxyd of tin, to unite with the ammoniac acid, and the oxyd of tin, in its turn, ſeizes on the ſulphur it finds in a ſtate of perfect diviſion, to form *muſive gold*. This laſt requires only to be heated, in order to exhibit its peculiar colour. It is to be obſerved, that in this inſtance the *muſive gold* ſeems to have been formed in the humid way.

A ſolution of tin in the muriatic acid was precipitated by a ſolution of ſulphure of potaſh. The precipitate was of a dark colour, approaching to yellow. By diſtillation, ſulphureous acid was diſengaged, and a little ſulphur ſublimed into the neck of the retort; the reſidue was *muſive gold*. This, therefore, may be conſidered as another inſtance of the formation of this ſubſtance in the humid way.

Muſive gold was ſubjected to diſtillation in a ſtrong heat; a conſiderable quantity of ſulphureous acid gas was diſengaged, and ſome ſulphur ſublimed into the neck of the retort; the reſidue was a black ſhining metallic maſs. It ſeems almoſt ſuperfluous to remark, that the ſulphureous acid gas muſt have been formed by the combination of a portion of the ſulphur with the oxygen of the oxyd of tin. The change which takes place in this experiment, in the order of the affinities, is to be attributed in this, as in many other inſtances, to a difference in the degree of temperature.

Two hundred grains of charcoal in powder, with 600 of *muſive gold*, were introduced into a retort, and placed in a reverberatory furnace, and the neck of the retort connected with a chemico-pneumatic apparatus. By keeping the mixture in a red heat for three hours, about 100 cubic inches of an elaſtic fluid were diſengaged. The firſt portion of this gas which paſſed over, ſeemed to be carbonic acid, containing about 1-100th of ſulphurated hydrogen. This gas had alſo volatilized, and held as it were in ſolution, a large quantity of ſulphur, which was afterwards depoſited on the ſurface of the water, by which the gas was abſorbed. The gas diſengaged towards the end of the proceſs contained a greater quantity of ſulphurated hydrogen, till at laſt bubbles of pure hydrogen gas were evolved. The reſidue was a ſulphure of tin divided by charcoal.

Six hundred grains of *muſive gold* were digeſted for ſome hours in muriatic acid, but the colour remained unchanged. After being filtered and dried, it weighed ſtill 580 grains. The 20 grains that diſappeared were probably a ſulphure which had been mixed with the muſive gold; for when this ſubſtance was digeſted a ſecond time with muriatic acid, no loſs of weight could be perceived.

From theſe experiments it appears clearly, that tin, whether in its native ſtate or amalgamated with mercury, or combined with ſulphur, is uniformly oxydated during the production of *muſive gold*.

h Adet obſerved, that the fuming muriat of tin, when diluted with water, was capable of diſſolving a freſh portion of tin; and that, during the ſolution of this portion, no diſengagement of hydrogen gas was produced. It was the obſervation of this fact that led Adet to conclude, that muriatic acid, in the fuming muriat of tin, exiſted in the ſtate of oxygenated muriatic acid. *Annal. de Chem.* Tom. I. p. 5.

CHAPTER XVII.

CONCERNING LEAD.

LEAD is an imperfect metal, of a dull white, inclining to blue. The alchemiſts give it the name of *Saturn*, becauſe it abſorbs and devours, as it were, all the imperfect metals in its ſcorification, as will be ſhown in the ſequel. It is the leaſt ductile, the leaſt elaſtic, and the leaſt ſonorous of all the metals; it may be reduced into thin plates under the hammer, and does not harden by beating. No metallic ſubſtance has leſs tenacity. A wire of lead of one tenth of an inch in diameter, ſupports no more than twenty-nine pounds and a quarter, without breaking. It is the third metallic ſubſtance in the order of weight; a cubic foot of lead weighs 828 pounds, and it loſes in water between the eleventh and twelfth of its weight. It is very ſoft, and eaſily cut with a knife; has a peculiar and remarkable ſmell, which becomes ſtronger by friction. Its taſte is ſcarcely ſenſible in the mouth, but its effect is very manifeſt in the ſtomach and inteſtines, whoſe nerves it irritates, producing pain, convulſions, ſtupor, and palſy. It is ſuſceptible of a regular form: the Abbé Mongez obtained quadrangular pyramids, lying on their ſides, ſo that of the four faces one always is much the largeſt. Each pyramid is compoſed as it were of layers, or zones of other ſmall pyramids, commonly terminating in one ſingle acute pyramid.

Lead is rarely found native; Wallerius and Linnæus admit its exiſtence in this ſtate, but it is denied by Cronſtedt, Juſti, Monnet, &c. It is moſt commonly in the ſtate of an oxyd, of a neutral ſalt, or in that of an ore, united with ſulphur, and forming galena. The lead mines are commonly at conſiderable depths in the earth, and are ſituated both in mountains and in plains. Naturaliſts have diſtinguiſhed a great number of ores of lead; the moſt eſſential to be known are the following:

1. Native oxyd of lead. The *ſpathoſe* ores of lead muſt not be confounded with this oxyd, which contains the carbonic acid. It does not efferveſce with the nitrous acid, and is commonly in white grey ponderous ſolid maſſes, or mixed with

clay, ſand, and chalk. The colour of the clay accordingly, as it is more or leſs ferruginous, conſtitutes native *maſſicot* and *minium*, or the yellow and red oxyds. The native ceruſe of lead is often found on the ſurface of galenas.

2. The carbonat lead, or the combination of the oxyd of lead with the carbonic acid: This varies greatly in colour; it is white, black, brown, yellow, or green, according to the ſtate of the iron which alters it. It is in general called *ſparry lead ore*, becauſe it has the texture and cryſtallization of certain ſpars; it effervesces with the nitric acid, which diſengages the carbonic. The following varieties of this ſpecies are diſtinguiſhed:

Varieties.

A. *White ſpathoſe lead ore.* This is a carbonat of lead, ſlowly depoſited by water in a cryſtallized form; it has ſometimes a ſemi-tranſparency like ſpar; its cryſtals are uſually hexahedral priſms, truncated, or in cylindrical ſtriated columns, which appear to be compoſed of a great number of threads, or in ſmall fine needles. It is ſometimes found of a brilliant white, like the *ſilky gypſum.* Other ſpecimens are of a yellowiſh white. Some of the priſms are often fiſtulous. The white ſpathoſe lead ore abounds in Lower Britany, in the mines of Huelgoet and Poullaouen. Sage affirmed that the white lead ore is mineralized by the muriatic acid. Laborie aſſerted that it was a pure oxyd of lead, united *to fixed air*, or carbonic acid, and cryſtallized by water. The Academy of Sciences having cauſed the experiments of theſe two chemiſts to be repeated, adopted the opinion of Laborie; and Macquer has related the tranſaction in his Dictionary, at the article Ores of Lead. The ſpathoſe lead ore is ſometimes found in the ſame places as the galena, and ſeems to be a decompoſition of that ore which has loſt its ſulphur, and whoſe lead is in an oxydated ſtate; for it is not rare to find galenas, which are paſſing to the ſtate of white lead, as Romé de Liſle has well obſerved.

B. Some naturaliſts have admitted a black ore of lead. It is white lead altered by a ſulphureous vapour, and by that means is revived. It may be conſidered as a middle ſpecies, between white lead and galena, and is cryſtallized in ſtraight regular hexahedral priſms.

C. The green ſpathoſe lead. This mineral is of a green, more or leſs tranſparent; often yellowiſh, always mixed with ochre and iron clay. It is ſometimes without any regular form, and reſembles a kind of moſs. Such are moſt of the ſpecimens from the mines of Hofsgrund, near Freyberg in Briſgaw. Green lead ore is commonly cryſtallized in ſtraight and regular hexahedral priſms, terminated by hexahedral pyramids, either entire or truncated near their baſe. It is found in great plenty at St. Marie-aux-Mines, and at Tſchoppau in Saxony. It is proved that it owes its green colour to the mixture of iron, ſince it is always found in mines of that metal.

D. Spathoſe lead ore of the colour of peach bloſſoms. Mongez found this variety cryſtallized like white ſpathoſe lead, in the mines of Huelgoet.

E. Yellow ſpathoſe lead ore. This variety, cryſtallized in hexahedral tranſparent laminæ, has not been known till within a few years. The laminæ are from half a line, to four or five lines in diameter; they reſemble glaſs of lead.

3. Monnet has diſcovered lead combined with the ſulphuric acid. It is commonly in the form of a white maſs, ſoluble in eighteen parts of water. Sometimes it is blackiſh, cryſtallized in very ſtrong ſtriæ, or in friable ſtalactites: this laſt variety effloreſces in the air, and becomes converted into a true ſulphat of lead. On account of this effloreſcence it is that Monnet calls it *pyritous ore of lead.* Dr. Withering affirms, that there exiſts in the Iſle of Angleſea a large quantity of lead and iron mineralized together by the ſulphuric acid.

4. Lead appears to be combined with the arſenic acid in the red lead one of Siberia, of which Mr. Lehman firſt gave a deſcription in the year 1766. This ore is of a very beautiful red, and its powder reſembles carmine; it is often cryſtallized in oblique rhomboidal priſms. Mongez, who thinks that arſenic exiſts in its acid ſtate, in all the red ores of lead, has diſcovered another ore of a greeniſh yellow from Siberia, and containing arſenic like the following.

5. Gahn diſcovered the phoſphoric acid in a greeniſh lead

ore. There is likewiſe a yellow and reddiſh ore of this kind. If this be diſſolved in nitric acid, and the oxyd of lead precipitated by the ſulphuric acid, the phoſphoric acid may be obtained by evaporation of the ſupernatant liquor. Metherie and Tennant have confirmed the analyſis of Gähn by experiments made at Paris. De Laumont has given a memoir upon the native phoſphoric ſalt of lead, which is very abundant in Britany.

6. Lead is moſt commonly found combined with ſulphur. This ore is named *galena;* it is likewiſe called *alquifoux* in commerce. This ſulphure of lead is compoſed in general of laminæ, which have nearly the colour and aſpect of lead, but it is more brilliant, and very brittle. A great number of varieties of galena have been diſcovered, viz.

Varieties.

A. Cubic galena. Its cubes, which are of various ſizes, are found either ſingle or in groups. It is alſo found in regular octahedrons. There is a variety of it which Hauy calls an *octahedral cube;* its ſurface is compoſed of ſix ſquares and eight equilateral triangles. Some mineralogiſts have deſcribed it as a tube truncated at the angles.

B. Galena in maſſes. This has no regular configuration; it is very common at St. Marie.

C. Galena with large facets. It does not ſeem to compoſe regular cryſtals; but it is entirely formed of large laminæ.

D. Galena with ſmall facets. This appears to be formed like the mica, of ſmall white and very brilliant ſcales; it is called white ſilver ore, becauſe it contains a conſiderable quantity of that metal. The ores of the mines of Pompean in Britany is of this kind.

E. Small grained galena; ſo called becauſe it has a very cloſe grain. It is likewiſe very rich in ſilver, and is found with the foregoing ore. Galenas in general contain ſilver; none are known to be without it except that of Carinthia; but it has been obſerved that thoſe galenas afford the moſt whoſe facets or grains are the ſmalleſt. It ſeems as if ſilver, being in ſome meaſure a foreign ſubſtance in the combination of galena, prevented the regular cryſtallization of that ore.

F. Galena cryſtallized like ſpathoſe lead in hexagonal priſms, or cylindrical columns; it is found as well as the foregoing in the mines of Huelgoet in Lower Britany. It contains little ſilver, and ſeems to be merely ſpathoſe lead mineralized, without having loſt its form. Cryſtals of pure ſpathoſe lead, entirely covered with a very fine galena, are ſometimes found in the ſame piece, together with others which are abſolutely changed into galena throughout. Romé de Liſle poſſeſſes many ſpecimens of this kind. I have in my collection a ſpecimen of white lead ore, the baſe of whoſe priſms is abſolutely in the ſtate of galena; which proves the change we are ſpeaking of.

Galena is often found placed between two layers of blackiſh ochreous quartz, which contain much ſilver, though the metal is not apparent. Dolomieu, the author of this obſervation, apprehends that lead was originally mixed with the ſilver; but that the water having carried off the imperfect metal, left the fine metal in the gangue. Monnet has diſcovered, that many galenas effloreſce like pyrites. He affirms, that by waſhing one of theſe, whoſe ſurface was become white and effloreſcent, he obtained a true ſulphat of lead.

7. Lead is ſometimes naturally united with ſulphur, antimony, and ſilver. This ore, which is called *antimoniated galena*, is of a needled or ſtriated ſtructure like antimony. The ſemi-metal is known by the white flowers which riſe during calcination. It is found at Salberg and at St. Marie-aux-Mines.

8. There is another kind of galena, in which the lead is united to ſulphur, ſilver, and iron. This martial galena is harder, and more ſolid than the foregoing. It affords a yellow lead during its ſcorification.

9. Laſtly, In the ſtate of an oxyd lead is often found, together with galena, in ſandy or calcareous earths and ſtones.

As almoſt all the ores of lead, and eſpecially the galenas, contain a conſiderable quantity of ſilver, it is proper to make a careful aſſay of their contents. For this purpoſe, after having pounded and waſhed a certain quantity of the mixed ore, it is roaſted in a covered veſſel to prevent decrepitation. The galena does not loſe much by the roaſting. After it has paſſed this operation, it is weighed, and melted with three times its weight of black flux, and a ſmall quantity of decrepitated marine ſalt. The fixed alkali of the black flux abſorbs the ſulphur united to the lead; the coal of the tartar, which is a part of the ſame flux, ſerves to reduce a portion of the metal which is in the ſtate of an oxyd; and the marine ſalt oppoſes the evaporation of part of the matter contained in the crucible. After the fuſion a button of lead is obtained, which is to be carefully weighed, and then oxydated or vitrified, to ſeparate the lead from the ſilver it contains. But this aſſay cannot be greatly depended on, becauſe the alkali, which is uſed as a flux, forms with the ſulphur of the galena a ſulphure, or *liver of ſulphur*, which diſſolves a portion of the lead. And it muſt alſo be conſidered, that, in the large way, a reducing flux, ſo expenſive as the black flux, cannot be uſed. It is therefore more adviſeable to endeavour to melt the ore among the charcoal, in a reverberatory furnace, or alone, with the addition of ſome cheap matter, to abſorb the ſulphur, ſuch as a ſmall quantity of iron and glaſs gall.

Bergman propoſes to aſſay lead ores by the nitric acid. This acid diſſolves lead and oxydates iron, but does not affect ſulphur. The ſolution is precipitated by carbonat of ſoda, and 132 grains of precipitate repreſent 100 grains of lead in its metallic ſtate. If theſe ores contain ſilver, the oxyd of this metal is ſeparated by the ammoniac, which diſſolves it.

At Pompean, the lead ore which contains ſilver is heaped up, waſhed with great care on tables, and carried to the furnace, where it is firſt roaſted by a gentle heat, and afterwards melted by raiſing the fire. The melted lead is taken out of the furnace by a hole which anſwers to one of the ſides of its hearth, and which had been cloſed with clay. The lead is then caſt into pigs which contain ſilver. To ſeparate this precious metal, the lead is carried into another furnace, whoſe hearth is covered with aſhes, well waſhed, ſifted, and rammed down. On one of the ſides of the hearth of this furnace are placed two large bellows, oppoſite to which are two gutters, which are called *the paſſages of the litharge*. When the furnace is hot the lead is oxydated; part evaporates, and is ſublimed in ſmall chimneys which are over the paſſages of the litharge. Another portion of the metal is abſorbed by the bottom of the furnace; a third part, which is the moſt conſiderable, is oxydated, and even partly vitrified; this is called *litharge*. The bellows drive it out of the furnace, and likewiſe facilitate the oxydation and vitrification of the lead, by the quantity of air they blow on the ſurface of the metal in fuſion. When the litharge has been calcined by a moderate fire, it is in the form of a red ſcaly powder, which is called *litharge of gold*, on account of its colour. If the litharge has been more heated, and is in a more vitrified ſtate, and of a pale colour, it is called *litharge of ſilver*. Laſtly, When the furnace is heated ſtrongly, ſo as to melt the litharge completely, and to fuſe it in the form of irregular ſtalactites, it is called *freſh litharge*. When the operation is finiſhed, the ſilver contained in the lead remains in the furnace. This ſilver requires to be again refined, but in ſmaller maſſes, in order that the remaining lead it ſtill contains may be ſeparated.

The lead which has been oxydated in this operation of teſting, is afterwards melted in contact with charcoal, and contains ſcarcely any ſilver; it is then caſt into pigs, and expoſed to ſale. *Spathoſe* lead melts in contact with charcoal, in the ſame manner as the oxyds of lead.

Lead expoſed to heat, melts long before it becomes ignited. The heat neceſſary to hold it in fuſion is ſo inconſiderable, that the hand may be plunged in it when melted without pain; and in this ſtate it does not burn vegetable ſubſtances[a]. It is ſcarcely at all volatile, yet by a very ſtrong heat it fumes, and is reduced into vapours, like the more fixed metals. If it be ſuffered to cool very ſlowly after being melted, and the melted portion be poured off from that which is become ſolid, it is found to be cryſtallized in quadrangular pyramids, which we have already deſcribed.

Lead melted with the contact of air ſoon becomes covered with a grey and dull pellicle; this pellicle is carefully taken off, and reduced by agitation into an oxyd of a greeniſh grey, verging towards yellow. When ſeparated by the ſieve from the grains of lead with which it is mixed, and afterwards expoſed to a more violent red heat, it becomes of a deep yellow, and in this ſtate is named *maſſicot.* This laſt, ſlowly heated by a gentle fire, aſſumes a beautiful red colour, and is known by the name of *minium.* If maſſicot be too ſtrongly heated, it melts into glaſs without affording minium.

Lead by oxydation becomes heavier, by the quantity of about ten pounds in the hundred. It was this increaſe of weight, produced in oxydating lead, as well as the neceſſity of air for the operation, which cauſed John Rey, a phyſician of Perigord, to ſuſpect, that air is fixed in this metal during the proceſs. Dr. Prieſtley has ſince confirmed the opinion of John Rey, by obtaining vital air from *minium.* The oxyd of lead, though highly coloured, eaſily loſes this colour. If minium be heated rather too much, it becomes pale; if it more ſtrongly be urged by heat, it melts, without addition, into a tranſparent glaſs, ſo fuſible, that it penetrates the crucible, and eſcapes. But if one part of ſand be added to three parts of oxyd of lead, the ſand melts, by the aſſiſtance of the oxyd, into a beautiful amber coloured glaſs. The colour of this glaſs is not ſo deep, and reſembles that of the topaz, when two parts of the oxyd of lead and one of ſand, or pulverized flint, are fuſed together. A ſimilar quantity of the oxyd of lead added to common glaſs, does not alter its tranſparence, but gives it a greater degree of weight, and more eſpecially a kind of unctuouſneſs, which renders it capable of being cut and poliſhed more eaſily without breaking. This glaſs is very proper to form achromatic lenſes; but it is ſubject to veins, and to have a gelatinous aſpect. The Engliſh call it *flint glaſs;* our workmen find great difficulty in ſelecting pieces of any conſiderable magnitude, exempt from ſtriæ, in that which is imported from England. This great imperfection ſeems, in Macquer's opinion, to depend on the principles of the glaſs not being uniformly combined: for that purpoſe, it is required that it ſhould be long held in fuſion; but as the lead would by that means be diſſipated, the flint glaſs would loſe a part of its denſity and unctuouſneſs, which are its chief merit.

Though all the phenomena of oxydation and vitrification of lead prove that this metal unites with great facility to the baſe of pure air or oxygen, it is nevertheleſs one of thoſe metallic matters which adheres the leaſt forcibly with that principle, ſince it gives it out by the ſimple action of heat, as Dr. Prieſtley has ſhown. If *minium* be ſtrongly heated in a retort, vital air is obtained, and a portion of the oxyd is reduced into lead. All the oxyds, and even the glaſſes of lead, are eaſily decompoſed by combuſtible bodies. For this purpoſe it is ſufficient to mix them with charcoal, ſoot, greaſe, oil, or reſin, or, in a word, any inflammable ſubſtance whatever, and to heat them for a certain time, in order to obtain a button of lead. This metal has therefore leſs affinity with oxygen than many other metallic ſubſtances have. Though it reſembles tin in ſome of its properties, it is abſolutely oppoſite to it in its oxydation and reduction. Theſe phenomena prove ſtill more our explanation of one of the cauſes of the affinity of compoſition, viz. that the degree of affinity of two bodies muſt not be eſtimated by the facility with which they combine, but by the difficulty experienced in diſuniting them.

All the oxyds of lead, and eſpecially minium, have the property of becoming charged with a certain quantity of carbonic acid, when expoſed to air. If therefore it be deſired that an oxyd of lead ſhould remain in a ſtate of purity, it muſt be kept defended from the contact of air, or ſlightly heated before it is uſed, in order to ſeparate the carbonic acid it may have abſorbed.

Lead expoſed to air tarniſhes the more readily, accordingly as the air is damper. It contracts a white ruſt, which water carries off by little and little. This white powder is not a pure oxyd of lead, but is combined with the carbonic acid of the atmoſphere. The ſilver extracted from old lead, which has remained expoſed for a long time to the atmoſphere, ſhows that the lead, which was not deprived of its ſilver at the time it was firſt uſed, has been partly oxydated by the action of the atmoſpheric air; ſo that the ſilver which remained unaltered, is gradually augmented in proportion to the quantity of lead deſtroyed by the action of the atmoſphere.

Lead is not altered by pure water, becauſe the principles of the water are not ſeparated by that metal; yet the internal parts of lead pipes which conduct water are covered with a whitiſh cruſt, or a kind of *ceruſe*, which doubtleſs is produced by the action of the different ſubſtances contained in the water on this metallic ſubſtance. Mr. Luzuriaga has obſerved, that by agitating granulated lead in a ſmall quantity of water, with the contact of air, the metal becomes quickly oxydated.

Lead does not unite with earthy matters; but in its ſtate of oxydation, it accelerates the vitrification.

The action of the ſalino-terreſtrial ſubſtances, and cauſtic alkalis on lead, or its oxyds, are not known.

This metal is ſoluble in all the acids, but concentrated ſulphuric acid does not attack it, except it be boiling, and the lead be in ſmall pieces. In this proceſs ſulphureous acid gas paſſes over. When moſt of the acid is decompoſed, the mixture is white and dry, and ſeparates into two portions, on being waſhed with diſtilled water. The moſt conſiderable part is inſoluble in water, and is an oxyd of lead containing a little ſulphuric acid, formed by the oxygen which the metal has taken from the acid during the time of the diſengagement of the ſulphureous gas. This oxyd may be melted or reduced like that which is made by the combined action of fire and air; the portion diſſolved by the water is a combination of ſulphuric acid and oxyd of lead. This ſolution, by evaporation, affords ſmall needles of ſulphat of lead. Baumé and Bucquet have not ſpoken of this ſalt, but under that form. Monnet ſometimes obtained it in priſmatic ſhort columns. Sage blames this chemiſt, becauſe he affirms that he found ſulphat of lead to afford cryſtals in tetrahedral priſms. It is a very cauſtic ſalt, and requires at leaſt eighteen parts of water to diſſolve it. It is decompoſed by fire alone, and alſo by lime and alkalis.

The nitric acid appears to act very ſtrongly on lead. When this acid is well concentrated, and in ſmall quantity, the lead is quickly reduced into a white oxyd, by means of the oxygen which is ſeparated from the nitric acid, at the ſame time that the nitrous gas is diſengaged; but if the acid be more feeble, it is leſs decompoſed, and a ſufficient quantity remains to diſſolve the oxyd of lead. During this ſolution a grey powder is precipitated, which Groſſe took to be mercury; but Baumé affirms that this matter is nothing but a portion of the oxyd of lead; and I have ſeveral times in vain attempted to obtain mercury by ſublimation, and by urging this powder with a fire capable of reducing mercury, if it had been in the ſtate of an oxyd. This ſolution does not afford a precipitate on the addition of water. Its cryſtals, obtained by cooling, are of an opake white, in the form of flat triangles, whoſe angles are truncated. The ſame ſolution, by a ſlow evaporation of ſeveral months, afforded cryſtals, the largeſt of which was one inch in thickneſs, of the form of hexahedral pyramids, whoſe three faces are alternately large and ſmall, and whoſe point is truncated, ſo that each cryſtal is an eight ſided ſolid. Rouelle has deſcribed this ſalt very well. The nitrat of lead decrepitates in the fire, and melts with a yellowiſh flame when laid on an ignited charcoal. The oxyd, which is at firſt yellow, becomes quickly reduced into globules of lead [b]. This ſalt is decompoſable by lime and alkalis. The ſulphuric acid, though it acts but feebly on lead, has nevertheleſs a ſtronger affinity to the oxyd of this metal than the nitric acid. If pure ſulphuric acid, or any neutral, earthy, or alkaline ſulphuric ſalt be added to a nitric ſolution of lead, a white precipitate is formed in a very ſhort time: this precipitation takes place, becauſe the ſulphuric acid, ſeizing the oxyd of lead, forms with it ſulphat of lead, ſimilar to that which is prepared by the immediate combination of the ſulphuric acid with that metal.

The pure muriatic acid, by the aſſiſtance of heat, oxydates lead, and diſſolves part of its oxyd; but it is difficult to ſaturate it completely. This ſolution always has an exceſs of acid, but nevertheleſs affords, by a ſtrong evaporation, cryſtals in the form of fine and brilliant needles, as Monnet has obſerved. The muriat of lead is ſcarcely at all deliqueſcent. Lime and alkalis decompoſe it like the preceding ſalts. This metal becomes more readily and intimately combined with the muriatic acid, by adding the acid itſelf, or the acid united with an alkaline or earthy baſe, to a ſolution of nitrat of lead. A white precipitate is immediately formed, which is much more abundant than that produced by the ſulphuric acid, and reſembles a coagulum. It is a combination of the oxyd of lead with the muriatic acid, which has ſeparated the oxyd of this metal from the nitric acid. This ſalt falls down, becauſe it is much leſs ſoluble in water than nitrat of lead; if it be expoſed to heat, it gives out vapours, whoſe taſte reſembles ſugar, and melts into a brown maſs, called *corneous lead*, becauſe it partly reſembles the ſilver which is diſtinguiſhed by the ſame name; it is ſoluble in thirty times its weight of boiling water. The ſolution of this ſalt by evaporation cryſtallizes into ſmall, fine, and brilliant needles, which form bundles, or unite by one of their extremities in an obtuſe angle. Sage affirms, that this ſolution affords, by inſenſible evaporation, cryſtals in ſtriated hexahedral priſms. The ſolution of corneous lead is decompoſable by the ſulphuric acid, which occaſions a precipitate reſembling that before obtained from the ſolution of nitric acid. This diſcovery, due to Groſſe, has been verified by Baumé, and by all the chemiſts who have repeated the experiment; it detects an error in the eighth column of the table of affinities of Geoffroy, who aſſerts, that lead has a ſtronger affinity with the muriatic acid than with the other mineral acids [c].

All the ſolutions of lead are precipitated of a black or brown colour by earthy or alkaline ſulphures; a kind of galena being formed by the tranſition of the ſulphur to the oxyd of lead, which ſeems to ſhow that lead is in the ſtate of an oxyd in that ore. In theſe experiments a double decompoſition takes place, without a double elective attraction, becauſe the alkaline baſe of the ſulphure would decompoſe the ſulphat, nitrat, and the muriat of lead, without any other addition.

All the oxyds of lead are ſoluble in acids as readily as lead itſelf, and often with greater facility. Minium loſes its colour in theſe ſolutions. Lead does not act on the ſulphuric neutral ſalts, neither does it decompoſe ſulphat of potaſh by heat, as tin, zink, and antimony do.

Lead does not ſenſibly detonate with nitre. When this neutral ſalt in powder is thrown on the melted metal in a low red heat, it excites ſcarcely any commotion or apparent flame, though the lead is oxydated and vitrified by the alkali of nitre, and takes the form of ſmall yellowiſh ſcales, ſimilar to *litharge*.

Lead decompoſes ammoniacal muriat very well by the aſſiſtance of heat. This property is common to many of the metals. The oxyds of lead triturated with this ſalt, diſengage the ammoniacal gas in the cold; but if the mixture be heated in a retort, the decompoſition is very rapid, and a volatile, cauſtic, and very penetrating ammoniac, comes over. Some chemiſts have affirmed, that the volatile alkali obtained by *minium* effervefces with acids, and have thence concluded that this oxyd of lead contains carbonic acid. But Bucquet has obſerved, that this effervefcence is produced by a portion of ammoniacal gas volatilized by the heat produced during the combination of the alkali and the acid, and that it only takes place when concentrated acids are uſed. He has made very ingenious and deciſive experiments on this ſubject. After having introduced into a glaſs veſſel over mercury, ammoniac obtained by means of *minium*, he added a ſufficient quantity of ſulphuric acid, ſomewhat concentrated, for the ſaturating of the alkali. The ebullition, or diſengagement of gas, was immediately excited, which was quickly after abſorbed, and conſiſted merely of ammoniacal gas. Neverthelefs, ſince it has been diſcovered that the oxyds of lead, and eſpecially the red or *minium*, contain carbonic acid, which they abſorb from the atmoſphere, it is conceived that the ammoniac diſengaged by theſe oxyds muſt take up a part. The maſs which remains in the retort after the decompoſition of ſal-ammoniac by *minium*, is muriat of lead, which melts by a moderate heat into corneous lead, and is totally ſoluble in water. This maſs was employed by Margraaf in the proceſs for making the phoſphorus of urine.

Hydrogen gas very ſenſibly affects lead, by producing changeable colours of the rainbow on its ſurface, and revivifying its oxyds. *Minium*, in contact with this gas, becomes black, and of a leaden colour. Dr. Prieſtley has obſerved, that a tube of glaſs, containing hydrogen gas, ſealed hermetically, and expoſed ſeveral days to the heat of a ſand bath, was entirely covered on its inner ſurface with a black tinge, and that a vacuum, with drops of water, was formed in the tube. This valuable experiment is explained by the greater affinity which the hydrogen has to the oxygen than lead has; and this is likewiſe proved by the total incapacity of that metal to decompoſe water. Engliſh glaſs contains a large proportion of oxyd of lead. The hydrogen gas acted on this oxyd, and by degrees deprived it of its oxygen, with which it formed drops of water; the lead at the ſame time aſſuming the metallic colour.

Sulphur readily unites with this metal. When theſe two ſubſtances are melted together, a brittle compound is produced, of a plated texture, and a deep grey brilliant colour. This ſulphure of lead, which nearly reſembles *galena*, is much more difficult to melt than lead; a phenomenon peculiar to the combinations of certain metals with ſulphur. Thoſe which are very fuſible, become more difficult of fuſion when united to that ſubſtance, while ſuch as are difficultly fuſed acquire a great degree of fuſibility by this addition[d].

The alloy of lead with arſenic has not been examined. Nickel, manganeſe, cobalt, and zink, do not unite with lead by fuſion; antimony forms a brittle alloy with ſome brilliant facets, ſimilar in texture and colour to iron or ſteel, according to the proportions of the mixture, and of a ſpecific gravity more conſiderable than the two metallic ſubſtances, ſeparately taken, would compoſe.

Lead combines with biſmuth, and affords a metal of a fine and cloſe grain, which is very brittle. Mercury diſſolves lead with the greateſt facility; this amalgam is made by pouring hot mercury into melted lead. It is white and brilliant, and becomes ſolid at the end of a certain time. When triturated with the amalgam of biſmuth, it becomes as fluid as running mercury. It is proper to obſerve, that this ſingular phenomenon takes place in the union of three very fuſible, ponderous, and more or leſs volatile, metallic matters.

Lead unites very eaſily by fuſion with tin. Two parts of lead, and one of tin, form an alloy more fuſible than either of the metals taken ſeparately, and conſtitutes the ſolder of the plumbers. Eight parts of biſmuth, five of lead, and three of tin, compoſe an alloy ſo fuſible, that the heat of boiling water is ſufficient to melt it, as Darcet has diſcovered.

The alloy of lead with tin being employed frequently in economical uſes, and the firſt of theſe metals being capable of rendering utenſils made with the ſecond very dangerous for culinary or pharmaceutical purpoſes, it is an inquiry of conſiderable importance to aſcertain the proportion of lead, which very often amounts to more than the public regulations permit. Bayen and Charlard have deſcribed an excellent proceſs for determining the quantity of this dangerous metal contained in pewter, or other compounds of tin. It conſiſts in diſſolving two ounces of the ſuſpected metal in five ounces of a good pure nitric acid. The oxyd of tin is to be waſhed with four pounds of diſtilled water, and dried, and the water evaporated by the heat of a water bath. By this evaporation nitrat of lead is afforded, which being calcined, the weight of the reſidue ſhows the quantity of that metal contained in the tin, allowing a few grains for the augmentation of weight ariſing from oxydation, as well as the other metallic ſubſtances, ſuch as zink and copper, which the tin under examination may contain. Theſe chemiſts, by this method, aſcertained, that fine wrought tin or pewter contains about ten pounds of lead in the hundred, and that the common tin ſold in France under that name, often contains twenty-five pounds in the ſame quantity; an enormous doſe, ſufficient to expoſe thoſe who uſe veſſels made of this compoſition to the greateſt danger. Lead is almoſt conſtantly a part of the veſſels continually uſed, ſuch as meaſures for diſtributing fluids, more eſpecially wine. It ſcarcely need be obſerved, that a liquid, which quickly becomes acid, may unite with lead, and may convey into the viſcera of thoſe unfortunate perſons who drink it, the ſeeds of diſorders, ſo much the more dangerous, as their cauſe is not ſuſpected.

The pewterers have ſeveral methods of diſcovering the fineneſs of tin, and the quantity of lead it contains: ſimple inſpection often anſwers their purpoſe; and the weight and the noiſe produced in bending greatly aſſiſts their judgment. They have two kinds of aſſay; the one called *aſſay by the ſtone*, which conſiſts in pouring the melted tin into an hemiſpheric cavity, hollowed in a thunder ſtone, terminated by a channel. The phenomena which the tin exhibits in its cooling, its colour, the roundneſs of its ſurface, the depreſſion of its middle part, the noiſe which the tail of the aſſay bent backwards and forwards produces, are the chief ſigns which the intelligent workman takes notice of, and by long obſervation applies with conſiderable accuracy to aſcertain the fineneſs of the metal. But this aſſay uſed by the maſter pewterers at Paris does not appear to be ſo exact as the other practiſed by the maſters in the country, though rejected with diſdain by the former. This ſecond aſſay is called by *the ball or medal*, becauſe it conſiſts in pouring the tin intended to be aſſayed into a mould, which gives it the form of a ball, or a flat maſs ſimilar to a medal. The weight of this ſample is compared with a ſimilar volume of fine tin poured into the ſame mould; the more the tin under examination exceeds that of the ſpecimen in weight, the more it is alloyed with lead. Bayen and Charlard, with great reaſon, prefer this laſt aſſay, the principles of which are more certain than the circumſtances on which the workman who uſes the aſſay of the ſtone muſt ground his judgment.

Lead is uſed in a great number of works. It forms a part of many alloys, and is made into pipes for the conveyance of water. Its oxyds are employed in glaſs-making, and in the preparation of enamels. It is uſed to imitate the colour of yellow precious ſtones, and to give fuſibility to the glaze of earthen ware. Utenſils and veſſels proper for economical uſes are made with this metal, but not without danger in their uſe, as we have before obſerved. Fountains, or veſſels of lead, in which water is ſuffered to remain a long time, often communicate a noxious quality to it. Its vapour is dangerous to the workmen who melt it, and its taſte is ſtill more dangerous to ſuch as file and ſcrape it. This metal, lodged in certain parts of the ſtomach and inteſtines, produces violent cholics, often accompanied with vomiting a very brown bile, and characterized by the flatneſs of the belly, and ſinking of the navel. It has been obſerved, that, in ſuch caſes, antimonial emetics and purges have been attended with great ſucceſs. Navier adviſes the different alkaline ſulphures in caſes of poiſoning by the preparations of lead, as well as in ſuch as are produced of arſenic and corroſive mercurial muriat; and it is more particularly in the palſy and tremblings which commonly remain after the *colica pictonum*, or painters cholic, that this phyſician boaſts of the good effects of alkaline ſulphure and ſulphureous waters. At all events, when theſe facts are duly conſidered, we ought to avoid the internal uſe of preparations of lead, and only apply it as an external medicine; and even in this laſt caſe it ought not to be adminiſtered but with all that care and caution which are required in the uſe of a ſtrong repellent.

NOTES ON CHAPTER XVII.

LEAD.

[a] LEAD is ſaid to melt in a heat of about 540° of Fahrenheit's ſcale.

[b] If this ſalt be diſtilled in cloſe veſſels with a ſtrong heat, it gives out a conſiderable quantity of oxygen gas. Mixed with inflammable ſubſtances, it detonates in the fire, and has, on that account, been termed *fulminating lead.*

[c] Fluoric acid diſſolves lead, and forms with it in the heat a ſweetiſh ſolution, which on evaporation depoſits a ſalt difficultly ſoluble in water. Fluat of lead does not part with its acid in the fire. It is decompoſed by the ſulphuric and muriatic, but not by the nitric acid.

Boracic acid combines with the oxyd of lead, but this combination is moſt readily effected by adding a ſolution of borax to a ſolution of nitrat of lead. Borat of lead is difficultly ſoluble in water; in the fire it melts into a white tranſparent glaſs.

Phoſphoric acid in the moiſt way has only a very weak action on lead, but it precipitates it from its ſolution in nitric acid, and forms with it a ſalt very difficultly ſoluble in water. Phoſphat of lead melts in a moderate heat into a glaſs, which, with the addition of a little charcoal, may be decompoſed by the blowpipe. This ſalt is ſoluble in the nitric acid; the ſulphuric and muriatic acids decompoſe it.

Tartaric acid diſſolves the oxyd of lead, and forms with it a ſalt very difficultly ſoluble in water. This ſalt may be decompoſed without addition by the fire, and the lead reduced to the metallic ſtate. Tartaric acid takes lead from the nitric and muriatic acids, but it is itſelf diſengaged from it by the ſulphuric. Nitric acid diſſolves the tartarit of lead.

Oxalic acid diſſolves the oxyd of lead, and forms with it a ſalt, which, with an exceſs of acid, becomes ſoluble in water. It ſhoots into needle-ſhaped cryſtals which ſuffer no change in the air, are inſoluble in ſpirit of wine, and in cloſe veſſels are decompoſable by the fire. Oxalic acid is ſuperior in affinity for lead to the nitric and muriatic acids, but inferior to the ſulphuric.

The citric acid combines with the oxyd of lead, and forms a ſalt difficultly ſoluble in water. This acid decompoſes the acetat of lead.

The malic acid diſſolves the oxyd of lead, and forms with it a compound very difficultly ſoluble in water. An alkaline or earthy malat decompoſes, by double affinity, the acetat of lead. By diſengaging the malic acid from the combination which is formed, it may be obtained perfectly free of all acetic acid.

Benzoic acid diſſolves the oxyd of lead by boiling in water. The ſolution has a ſweetiſh taſte, and ſhoots into looſe foliated ſhining cryſtals. Theſe diſſolve readily in water and ſpirit of wine, and are not changed by expoſure to the air.

Succinic acid diſſolves the oxyd of lead by boiling them together in a large quantity of water. After being evaporated and cooled, the ſolution depoſits foliated ſhining cryſtals, which are eaſily ſoluble in nitric acid, but difficultly ſo in water. This ſalt is decompoſed in the fire and by alkalis. Succinic acid diſengages lead from its ſolution in acetic acid.

The oxyds of lead ſeem to have a ſtrong attraction for carbonic acid, but this acid does not diſſolve lead either in its metallic or oxydated ſtate.

Pruſſiat of potaſh precipitates lead from its ſolution in acids of a white colour. An exceſs of pruſſiat diſſolves the precipitate. The ſolution, which has a yellowiſh brown colour, contains pruſſiat of lead.

The gallic acid precipitates lead from its ſolution in nitric acid, of a white colour, which becomes dark by drying. The gallat of lead is but little known.

[d] Phoſphorus enters into fuſion with lead. The phoſphure has a metallic luſtre, and the colour of lead. The phoſphorus may be ſeparated again by the combined application of heat. See *Gren's Handbuck. Bley.*

CHAPTER XVIII.

CONCERNING IRON.

Iron, called *Mars* by the alchemiſts, is an imperfect metal, of a white livid colour, inclining to grey, internally compoſed of ſmall facets. It is ſuſceptible of a very beautiful and brilliant poliſh, and its hardneſs and elaſticity are ſuch, that it is capable of deſtroying the aggregation of all the other metals.

Iron has a conſiderable ſmell, eſpecially when rubbed or heated. It likewiſe has a very evident ſtyptic taſte, which acts ſtrongly on the animal economy. Next after tin, it is the lighteſt of metallic ſubſtances; a cubical foot of this metal, when forged, weighs 580 pounds. It may be extended into plates by beating; but as it is very hard, and becomes ſtill harder under the hammer, it cannot be made into leaves. Its ductility, when drawn into wire, is much more conſiderable; very fine wires being made of this ſubſtance for muſical purpoſes: this property appears to depend on its tenacity. In fact, iron is the moſt tenacious of all metals, except gold. An iron wire, of one tenth of an inch in diameter, ſuſtains a weight of 450 pounds without breaking.

Pure iron has a peculiar cryſtalline form. In the furnaces, where the metal has been ſuffered to cool ſlowly, quadrangular, articulated, and branching pyramids, formed of octahedrons, implanted one in the other, were found. This obſervation was made by Grignon, maſter of the forges at Bayard, in Champagne. Laſtly, Beſides all the properties which iron partakes in common with every other metallic ſubſtance, it preſents three which are peculiar to itſelf. The firſt is magnetiſm, or the property of being attracted by the magnet, and of itſelf becoming a very good magnet, either by remaining a long time in an erect poſition, or in the direction from ſouth to north; or by ſerving as the conductor to the electric fire of thunder, as many facts atteſt; or by being ſtrongly rubbed againſt another piece of iron. The ſecond property is that of taking fire, or ſuddenly melting by the ſtroke of a flint; a phenomenon to which the poets univerſally attribute the diſcovery of fire by the firſt men. The third property which diſtinguiſhes it is, that it is found with manganeſe in plants and animals, whoſe fluids it partly colours. It is likewiſe probable that theſe organic beings themſelves form this metal; for ſuch plants as grow in pure water contain iron, which may be extracted from their aſhes.

Iron is a metal which is very abundant in nature, ſince, independently of that which plants and animals contain, it is found in almoſt all coloured ſtones, bitumens, and in almoſt all metallic ores. But we ſhall in this place attend only to the mineral ſubſtances which contain it in ſuch large quantities as to be worth extracting. In theſe ores, which are very numerous, iron is either in the metallic or oxydated ſtate, or elſe mineralized by different ſubſtances.

1. Native iron is known by its colour and malleability. It is very rare, and is only found occaſionally in iron mines. Margraaf found it in a fibrous form at Eibenſtock in Saxony. Pallas diſcovered in Siberia a maſs of 1600 pounds; and Adanſon affirms that it is common at Senegal. Some naturaliſts think that theſe native ſpecimens of iron are produced by art, and have been buried in the earth by accidents.

2. The black ores of iron appear in general to belong to a black oxyd of iron, more or leſs pure. Black iron is known by its colour, by its property of being more or leſs attracted by the loadſtone, and by being not at all ſoluble in acids. This iron is ſometimes cryſtallized in the form of polyhedrons, or in rounded laminæ, and preſents different ſpots of very brilliant rainbow colours; ſuch is that of the Iſland of Elba. This iron forms a very conſiderable mountain, from which it is dug at the ſurface. The Swediſh iron ore is likewiſe black, but is not cryſtallized. It is in maſſes more or leſs ſolid, mixed with quartz, ſpar, aſbeſtos, &c. it is often hard enough to take a poliſh, and its ſurface appears as it were compoſed of ſpeculæ, for which reaſon it, as well as the preceding, is called *ſpecular iron ore*. It is found united in quarries of very conſiderable extent. This ore varies in its colour; when it is perfectly black it is ſtrongly attracted by the magnet; the blueiſh is leſs attracted, and the grey ſcarcely at all. The iron of Norway is likewiſe black, but it is commonly in ſmall ſcales, like mica, often mixed with garnet and

ſchorl. Black iron ore has ſometimes the form of grains. It is likewiſe cryſtallized in cubes, which has cauſed it to be denominated by ſome naturaliſts, *galena of iron*, or *eiſen-glanz*. When the micaceous ore of iron is black, it is called *eiſen-man*, eſpecially if the ſcales be very large. When they are red, and the powder which covers them is of the ſame colour, it has the name of *eiſen-ram*. Iron ore in very regular, black octahedral cryſtals, and diſperſed on a kind of ſhiſtus, or hard ſteatites, which comes from Sweden, Corſica, &c. appears to belong to this claſs. It is attracted by the magnet, and is very brittle. The laminated and brilliant iron ore of Fremont likewiſe belongs to this ſpecies.

Though the different kinds of iron ore, conſidered in this article, ſeem to have a ſtrong analogy with each other, ſeveral mineralogiſts have conſidered them as very different, and have arranged them accordingly. This variety of opinions ariſes from the exact knowledge of their nature not being yet obtained. It ſeems, that among thoſe ores there are ſome more or leſs approaching to the metallic ſtate, as the octahedral iron ore of Corſica and of Sweden, which Mongez compares to the martial Æthiops. This is ſtrongly attracted by the magnet. Others, on the contrary, approach more to the ſtate of oxyd, as the iron of the Iſle of Elba, and eſpecially the *eiſen-man*, and *eiſen-ram*, which are not acted on by the magnet.

The ores from the Iſland of Elba ſeem to be only black oxyds of iron, ariſing from the carbonat of iron, reduced by means of fire. In this way Vauquelin has imitated them with great ſucceſs. To theſe details reſpecting the black irons I ſhall here ſubjoin ſome facts, obſerved by Abbé Hauy of the Academy of Sciences. He diſtinguiſhes two primitive forms in theſe irons, which, according to him, announce two ferruginous ſubſtances of different natures.

The one is the regular octahedron, which is peculiar to the iron of Corſica. Its cryſtals are ſtrongly attracted by the magnet. The ſpecular iron of *Mont d'Or*, in octahedral ſegments, is a variety of this ſort.

The other form is that of the cube, and belongs particularly to the iron ore from the Iſland of Elba, of which there are two principal varieties: 1. The iron in very obtuſe rhomboids;

2. The iron with ſix pentagons and eighteen triangles. Theſe varieties attract the magnet very feebly. Hauy, by filing them, obtained an unctuous reddiſh powder like that of the red micaceous iron, or the *eiſen-ram* of the Germans.

3. Iron is very often in the ſtate of ruſt, more or leſs oxydated. It then forms the ochreous ores of iron. All earths, which are of a brown or red colour, are of this kind.

4. The iron ores, which are called *bog ores*, muſt not be confounded with the ochres: theſe ores indeed contain oxydated iron; but this oxyd is combined with the carbonic and phoſphoric acids, which appear to ariſe from the decompoſition of vegetables; it is diſtinguiſhed into rich and poor bog ores, fuſible and refractory iron. The rich iron is not much ruſted, and contains only a very ſmall quantity of earth. Fuſible iron is that which melts eaſily, and affords caſt iron of a good quality. The metal is united in its ore to ſeveral fuſible ſtones. Dry or refractory iron is more oxydated, and mixed with infuſible ſubſtances. All the bog ores of iron are commonly diſpoſed in beds, in the manner of ſtones, and ſeem to have been depoſited by waters. It is very often in the form of ſpherical bodies, either flat or irregular. Organic matters, ſuch as wood, leaves, bark, ſhells, &c. are not unfrequently found in the ſtate of bog ores. This kind of converſion, or tranſition, ſeems to indicate a ſort of analogy between this metal and organic ſubſtances. A portion of phoſphat of iron contained in theſe ores the moſt common of all, communicates to this metal the property of being brittle when cold. Bergman, who was acquainted with this ſtate of iron, without having determined its nature, called this phoſphat of iron *ſiderite*; ſome German chemiſts have ſince called it *water-iron*. We ſhall hereafter explain the means of ſeparating this ſalt from iron, which is brittle in the cold.

5. The eagle ſtones, or *ætites*, is a variety of the bog ore; they are bodies of different forms, commonly oval or polygynous, compoſed of concentric layers, diſpoſed round a nucleus, which is frequently moveable in the centre of the ſtone. The drying and ſhrinking of theſe layers forms a middle cavity, in which ſeveral fragments, more or leſs conſiderable, exiſt looſe or detached. This ſtone has received the name it bears, be-

cauſe it was formerly thought that the eagles depoſit it in their neſt, and that it has the property of facilitating births. Hence it has been concluded, that this ſtone acts ſtrongly on the fœtus in utero. Some authors have even affirmed, that it was poſſible to accelerate the labour of women by tying the eagle ſtone to their leg, or to retard it by tying it to their arm.

6. The *hematites* are a ſort of muddy iron ore, which ſeem to be formed in the manner of ſtalactites; its name comes from its colour, which is commonly red, or of a blood colour, though this colour is ſubject to variations. The hematites is uſually compoſed of layers which cover each other, and are themſelves formed of convergent needles; the external part of this ore is covered with tubercles; it is not only diſtinguiſhed by the colour, but by the form. Such are the hematites in needles found in Lorrain; the tuberclated hematites are in the form of bunches of grapes, or the hematites botrytes, &c. Theſe ores are often found together with the muddy iron ore, and are depoſited on a variety of different bodies.

7. The *loadſtone* is an ochreous iron ore, very hard and refractory, which ſome perſons however imagine to be very near the metallic ſtate. It is known by its property of attracting ſteel filings, and is found in Auvergne, and in Biſcay in Spain; the varieties are diſtinguiſhed by their colours.

8. *Emery, ſmyris*, is a grey or reddiſh iron ore, which ſeveral mineralogiſts conſider as a ſort of hematites; it is very hard, is very refractory, and is abundantly found in the Iſlands of Jerſey and Guernſey. It is reduced into powder, in mills, and in this ſtate is uſed to poliſh glaſs and metals.

9. *Spathoſe iron ore* is an oxyd of iron combined with the carbonic acid, and worn by water; it is uſually of a white colour, though all the ſhades of grey, yellow, and red are found. It is always diſpoſed in laminæ of different thickneſs, ſemitranſparant like ſpar; is heavy, and often regularly cryſtallized. Conſiderable quarries of this ore, frequently mixed with pyrites, are wrought; as that of Allevard in Dauphiny. Sometimes it is mixed with grey ſilver ore, as the iron of Baigorry; or with mangaueſe, as that of Styria. Some mineralogiſts think, that it is a ſpar in which the metallic oxyd has been depoſited. Spathoſe iron ore is decompoſed without addition

in cloſe veſſels, and affords carbonic acid; the iron remaining in a black powder, is ſtrongly attracted by the magnet, and eaſily melts by the action of a conſiderable heat. The manganeſe which it often contains renders it changeable in the air, and cauſes it to aſſume a brown colour, in proportion as it loſes its form and conſiſtence.

10. Nature likewiſe preſents iron in the ſaline ſtate, united to the ſulphuric acid, and forming ſulphat of iron, or green copperas. This ſalt is found in the galleries of iron mines, eſpecially thoſe that contain *pyrites;* it is ſometimes found in green cryſtals, or in the form of fine ſtalactites; and at other times it is not ſo pure. When it has loſt the water of its cryſtallization it is of a white or greyiſh colour; it is then called *ſori;* if it has ſuffered a calcination rather ſtrong, it is yellow, and called *miſſy;* if the calcination be carried on ſtill farther, a conſiderable portion of the red ſulphat of iron will be obtained, called natural *colcothar,* or *chalcites.* If mixed with certain inflammable matters, this ſalt is called *melantari,* on account of its black colour; all theſe different matters have received the name of *lapides atramentarii,* becauſe, like the ſulphat of iron, they are proper to make ink.

11. Iron is often found united to ſulphur, and then conſtitutes *martial pyrites.* This kind of ore has received the name of pyrites, becauſe it is ſufficiently hard to give numerous ſparks when ſtruck with the ſteel; we call this combination native ſulphure of iron. The *martial pyrites* are commonly in ſmall red maſſes, ſometimes regularly formed; they are uſually ſpherical, cubical, or dodecahedral, but their form varies conſiderably, as may be ſeen by conſulting the Pyritologia of Henckel.

The Abbé Hauy, who has attentively ſtudied the ſtructure of ferruginous pyrites, has obſerved the following principal varieties in their form:

Varieties.

1. The ſmooth cube; this is the primitive form of the mineral.
2. Pyrites in regular octahedrons.
3. In cubo-octahedrons; this is the cube of which the angles are truncated.

4. Dodecahedral pyrites, with pentagonal planes.
5. Cubical pyrites ſtriated in three different directions. He has ſhown (*Mem. de l'Acad.* 1785. p. 218.), that the cube, the ſtriæ of which had ſo much embarraſſed Stenon and Mairan by the diverſity of their directions, was nothing but a modification produced by the ſudden cryſtallization of the dodecahedron with pentagonal planes.
6. *Pyrites*, with twenty triangular faces, eight of which are equilateral, and twelve iſoſceles.
7. *Pyrites*, with thirty-ſix iſoſceles triangular faces, of which twelve are broader and longer than the other twenty-four.
8. Globular pyrites, prickly, with octahedral points; this ſeems to be of a different nature from the former.

Some pyrites are brown on the outſide, and of the colour of iron; moſt are yellowiſh, and conſiderably reſembling copper ores, even at their ſurface. All are yellow, and, as it were, coppery within. Pyrites are commonly diſperſed, and particularly in copper mines, in the neighbourhood of iron mines and in clays, and coal mines. The upper ſtratum of the latter is almoſt always pyritous. All the ſeveral kinds of pyrites are eaſily decompoſed. A ſlight degree of heat is ſufficient to deprive them of their ſulphur. They are almoſt always ſpontaneouſly changed when expoſed to the air, eſpecially in a moiſt place. They ſwell, burſt, loſe their brilliancy, and become covered with an efflореſcence of a greeniſh white, which is ſulphat of iron. It ſeems that this alteration, which is called *vitriolization of the pyrites*, depends on the united action of air and water on the ſulphur. Sulphuric acid is thus formed, which diſſolves the iron, and riſes above the ſurface of the pyrites like a kind of vegetation, which gradually ſeparates the ſmall pyramids which compoſe this mineral. All pyrites do not effloreſce with the ſame facility. The globular pyrites, whoſe colour is very pale, and texture cloſe, become vitriolized very quickly. The others, which are of a brilliant yellow, or of the colour of copper, and are formed of ſmall laminæ, very evenly applied on each other, do not effloreſce but with great difficulty, and muſt be very carefully diſtinguiſhed from the foregoing, becauſe they differ from them in colour, form, texture, and other properties.

12. Iron is found combined with arſenic, both being in the metallic ſtate. This ore, which is the true *miſpickel*, is white, brilliant, granulated, or in facets, and does not contain ſulphur, as the arſenical pyrites, properly ſo called, does. Wolfram was formerly conſidered as an arſenical iron ore, but it is now known to be an ore of tungſten.

13. Iron is ſometimes found in the form of a blue powder, of a more or leſs deep colour. In this ſtate it is called *Pruſſian blue*, or *native pruſſiat of iron*. It is mixed with vegetable earths, and eſpecially with turf.

14. Laſtly, Iron being the moſt abundant of all the metals, is frequently found mixed with ſand, clay, chalk, and is the colouring matter of a great number of different earths and ſtones.

Iron ores are aſſayed after the following manner, by the dry way. After reducing them into powder, they are mixed with double their weight of pounded glaſs, one part of calcined borax, and a ſmall quantity of charcoal in powder; the mixture is exactly triturated, and put into a crucible; a ſmall quantity of marine ſalt is added, the crucible is then covered, and the heat raiſed to melting. When the maſs is very ſlowly cooled, iron, more or leſs malleable, and in a ſmall ſpherical button, often cryſtallized at its ſurface, is found.

Bergman propoſes to aſſay iron ores by the humid way. He uſed the muriatic acid to diſſolve the iron, and precipitated it by a pruſſiat of alkali. If other metals were mixed with the iron, he calcined them, and ſeparated them by the nitric and acetic-acids, and afterwards diſſolved the iron by the muriatic acid.

The treatment of iron ores varies according to the ſtate in which the metal is found. There are ſome ores which require no preparation before the ſmelting; others require to be pounded and waſhed, and ſome to be roaſted, in order that they may become more friable and fuſible.

The bog ores and ſpathoſe iron ore, are examined in the ſame manner, by ſmelting them with charcoal. The furnaces in which iron is melted are of various heights, from twelve to eighteen feet; their cavity repreſents two quadrilateral pyramids, which join at their baſe about the middle of the height of the furnace. At the bottom of the furnace an aperture is made, from which the melted metal is to flow out; this aperture, which is cloſed with earth, correſponds with a triangular cavity, hollowed in ſand, and intended to receive the melted iron. The proceſs is begun by throwing ſome lighted bruſhwood into the furnace, and afterwards charcoal, with the ore, and certain fluxing matters; theſe are commonly of calcareous ſtone, with certain argillaceous ſtones, and ſometimes quartz and flints. The ſtones, the charcoal, and the ore, are alternately thrown into the furnace, obſerving to cover the whole with a bed of charcoal, which muſt riſe to the upper opening of the furnace. The ſmelting is performed by the help of two ſtrong pair of bellows; and the iron melts paſſing through the charcoal, which reduces it. The ſtony matters added to the ore, becoming melted and vitrified, facilitate the fuſion of the iron, which begins at the narroweſt part of the furnace. The melted metal is collected at the bottom, and by opening the anterior aperture of the furnace, it is ſuffered to run out into the cavity in the ſand; it is then called *crude* iron. A vitreous matter called *ſlag*, paſſes after the iron, and conſiſts of the ſtones added to facilitate the fuſion. Its colour is green, whitiſh, blue, or yellow, which it receives from a portion of the oxyd of the iron.

The metal is brittle, and has not the ductility of iron. Metallurgiſts are not agreed concerning the cauſe of this property of caſt iron. Some think that it is owing to a portion of the vitreous matter; others attribute it to part of the oxyd of iron not being reduced. Brandt ſuppoſed it to ariſe from arſenic, and Sage thinks that it is produced by zinc. Bucquet conſidered caſt iron as iron not well reduced, and ſtill containing a portion of metallic oxyd interpoſed between its parts. Bergman, who made many experiments on iron, has proved, that the brittleneſs of caſt iron depends on a certain quantity of foreign matter, which he ſuppoſed to be a peculiar ſubſtance, and called *ſiderite*. It has been ſince diſcovered, that ſiderite is a compound of iron and phoſphoric acid, and that it is likewiſe found in ſome kinds of malleable iron, as we ſhall hereafter ſhow.

The true cauſe of the brittleneſs, fuſibility, granulated texture, and all the other properties of caſt iron, has been put out of doubt by the valuable reſearches of Vandermonde, Monge, and Berthollet. They have proved that crude iron contains oxygen and charcoal: this laſt has been abſorbed during the fuſion in the ſmelting furnaces. It is to the ſeveral quantities of theſe two foreign ſubſtances that caſt iron owes its different qualities.

Metallurgiſts diſtinguiſh ſeveral kinds of caſt iron, white, grey, black, &c. That which is of a grey brown, with blackiſh ſpots, is called ſpeckled iron. The white caſt iron is of the worſt quality, and approaches to the character of brittle metals; the grey is of an intermediate quality between the firſt and the black, which is the beſt, and affords iron of a good quality.

Theſe different characters depend on the quantity of oxygen, and more eſpecially of charcoal, contained in the crude iron. When the charcoal is very abundant, and uniformly mixed, the caſt iron is black; a ſomewhat ſmaller quantity of that ſubſtance forms the grey caſt iron; an imperfect mixture too quickly made, and ſuddenly cooled, conſtitutes ſpeckled iron; and the white crude iron contains the leaſt poſſible quantity of charcoal. All theſe qualities influence the nature and uſe of crude iron, and eſpecially its convertibility into malleable iron. The philoſophers above quoted have diſcovered, that when crude iron is fuſed, there is always ſeparated a portion of charcoal intimately united to a ſmall quantity of iron, or carbure of iron. This compound, hitherto called plumbago, covers the ladles with which the caſt iron is taken up and poured out.

To convert crude into malleable iron, it is neceſſary to deprive it of charcoal and oxygen. A ſtrong heat, which thoroughly penetrates the whole maſs, is neceſſary to obtain this reduction. It may be eaſily conceived, that at a high temperature the charcoal muſt burn by ſeizing the oxygen, and will diſengage itſelf with efferveſcence in the form of carbonic acid gas. For this purpoſe it is taken to the refining ſurface. This is a hearth ſomewhat hollow, in which a maſs of crude iron is placed, and covered with a large quantity of charcoal. The fire is urged by bellows until the iron melts, in which ſtate it is wrought or kneaded, and repeatedly turned over with proper inſtruments. This agitation cauſes it to preſent a large ſurface, ſo that the portions of charcoal take the oxygen from the iron, are burned, and give out carbonic acid gas. The metal appears likewiſe to be deprived of a portion of *ſiderite*, or phoſphat of iron. It is then carried to the hammer, to be wrought into bars. The hammering, by bringing the parts of iron nearer together, facilitates the ſeparation of the ſiderite, and the portion of carbure, and of oxyd of iron which the metal ſtill contained, and by that means completes what was left defective by the fuſion. This heating and hammering is repeated a number of times, till the iron has acquired the deſired degree of perfection.

Two kinds of forged iron are diſtinguiſhed; ſoft iron and ſteel. Soft iron is very ductile, and when it is broken by bending backwards and forwards, it draws out, and appears to be compoſed of fibres. This fibre or nerve, however, is only produced by the manner of breaking, and does not appear at all when the ſofteſt iron is broken ſhort and ſuddenly; at the ſame time that iron of the worſt quality will appear fibrous if it be broken ſlowly and cautiouſly. The quality of iron may be eſtimated much better from its grain than from its fibres. Caſt iron is more brittle, and has a large grain, which appears as if formed of ſmall ſcales. It is diſtinguiſhed into *hot ſhort iron*, and *cold ſhort iron*. The cauſe of this brittleneſs is at preſent known: the hot ſhort iron contains much more ſiderite than other iron, and the quantity of this phoſphure of iron is leſs and leſs in other iron, to the ſofteſt, which contains none at all. In order to ſeparate this compound from iron, and to determine its quality, the metal is diſſolved in diluted ſulphuric acid, and a white precipitate, conſiſting of phoſphat of iron, ſubſides gradually, which is collected and weighed[a].

Iron may be converted into ſteel by artificial means. For that purpoſe ſhort bars of iron are encloſed in an earthen box or veſſel, filled with a cement, commonly compoſed of very combuſtible matters, ſuch as ſoot, or the coal of animal matters, animal oil, to which is uſually added, aſhes, calcined bones, marine ſalt, or ſal-ammoniac; but theſe matters appear to do oftener harm than good. The box being well cloſed, is heated for ten or twelve hours, till the bars become white, and are ready to melt. In this operation the iron becomes purified, and is completely reduced by the aſſiſtance of the combuſtible matters with which it is ſurrounded; the portions which were not perfectly in the metallic ſtate, aſſume that ſtate; and the phoſphure of iron, if it ſtill remains, appears to be entirely decompoſed. The iron being ſoftened and dilated, abſorbs the charcoal which ſurrounds it; and the ſteel of cementation is nothing elſe but a combination of pure and well-reduced iron with charcoal. It differs from iron in containing charcoal, and from caſt iron in this, that the crude iron contains not only charcoal, but a greater or leſs quantity of oxygen. If caſt iron be deprived of its oxygen without ſeparating the charcoal, or by giving it a new quantity, ſteel will be produced without refining the iron[b]. Steel is much more fuſible than iron, for which reaſon the bars which are converted into ſteel by cementation, are ſoftened to that degree, that the carbonic acid, which is diſengaged in bubbles during the action of heat, forms ſmall bliſters, or very ſenſible cavities on its ſurface. This kind of ſteel is called *bliſter ſteel*. The differences of ſteel depend upon the greater or leſs reduction of the iron, the quantity of charcoal which it contains, and the more or leſs ſudden cooling it has been ſubjected to. The tempering brings the particles ſtrongly together, and renders it very hard, very dry, and very brittle.

It is evident that all the preparations to which iron is ſubjected, are neceſſary only becauſe that metal, being more difficult to fuſe than others, adheres very ſtrongly to oxygen, and has a ſtrong tendency to combine with it.

There are ſome iron ores, particularly the black iron ore, as for example, that of the Iſland of Elba, in which this metal is ſo abundant, and ſo little altered, that nothing more is neceſſary than to melt it. It is ſufficient if theſe be ſoftened under the coal in the refining furnace, and conveyed from thence to the hammer. This is called the *Catalan method*, and can only be uſed with ores that contain but a ſmall quantity of ſuch foreign matters as are capable of being converted into ſcoriæ.

Spathoſe iron ores afford an iron ſo pure, and ſo little reducible, that they melt very readily, and eaſily abſorb charcoal in their reduction, for which reaſon they are called *ſteel ores*[c].

The chemical properties of iron are very numerous, and in order that they may be the more perfectly underſtood, we ſhall conſider them as they exiſt in the ſofteſt iron.

Iron does not melt but by an extreme heat. When thrown in filings in the midſt of a burning fire, or even through the flame of a taper, it ſuddenly takes fire, and produces very brilliant ſparkles. Theſe are ſimilar to thoſe produced by the ſtroke of the ſteel againſt flint, and if collected on a white paper, they are found to be melted, and reſemble a kind of ſcoriæ. This metal, expoſed to the focus of the lens of De Trudaine, ſuddenly throws out inflamed and burning ſparkles. Macquer, who melted ſteel and iron in this lens, obſerved, that ſteel was the moſt fuſible, which ariſes from its combination with charcoal. Iron melted and ſuffered to cool ſlowly, takes a peculiar cryſtalline form, as we have already obſerved. Mongez deſcribed it to be a pyramid of three or four ſides.

The blow pipe, with vital air, cauſes the filings of iron to burn as rapidly as the focus of the lens of the Garden de l'Infant. If an iron wire turned in a ſpiral form, and terminated by a ſmall piece of lighted quick match, be plunged into a veſſel of vital air, the metal ſuddenly catches fire, and burns with a very remarkable degree of rapidity and deflagration. As, in all theſe fuſions, the iron becomes brittle and is oxydated, at the ſame time that it aſſumes a black colour, the workmen in iron, and all who have to do with this metal, do not conſider it as fuſible; and it is an axiom with them, that iron is abſolutely infuſible. It may be conceived, however, that this opinion, ſtrictly taken, is erroneous; for by a very ſtrong heat, and without the contact of air, iron melts with ſcarcely any alteration. In our accurate experiments, ſmall ingots of ſoft and ductile iron are obtained. Iron, though very hard and refractory, is very eaſily calcined or oxydated; when it begins to grow red, it combines with the oxygen, and burns without any apparent flame. A bar of iron kept red hot for a long time, becomes covered with ſcales, which may be beat off with the hammer. In theſe, however, the metal is only partly oxydated, ſince they are attractable by the magnet. A more perfect oxyd of iron is made, by expoſing filings of ſteel, and ſtill more quickly the ſcales of hammered iron, to heat under a muffle. They are converted into a reddiſh brown powder, not attractable by the magnet, and called *aſtringent ſaffron of Mars*. We call it the *red oxyd of iron*, and the ſcales the *black oxyd*. This laſt ſubſtance contains from 20 to 25 per cent. of oxygen; the red oxyd contains from 32 to 34. The oxyds of iron vary between theſe two degrees of oxydation; ſome are of a yellowiſh brown, others of a chocolate colour, and others of a beautiful red ſimilar to carmine: all theſe oxyds, when mixed with earthy matters, and expoſed to a very ſtrong heat, melt into a blackiſh and porous glaſs. They are reduced in part by heating them ſlowly in cloſe veſſels: if they have been expoſed for a ſhort time to the air, they give out a certain quantity of carbonic acid during their reduction; which proves that they attract this acid from the atmoſphere. This acid likewiſe comes from the charcoal contained in iron, which becomes acid by abſorbing the oxygen diſengaged during their reduction.

The red oxyds of iron are eaſily reduced with combuſtible matters. When mixed with a ſmall quantity of oil, and ſlightly heated in a crucible, it becomes black, and is ſtrongly attracted by the magnet. But they do not loſe all the oxygen which they contain in this operation, and paſs only to the ſtate of the black oxyd.

The pureſt iron expoſed to moiſt air, ſoon loſes its metallic brilliancy, becomes covered with a pulverulent cruſt, of a yellow brown colour. This matter is uſually called *ruſt*. Common iron is much more ſubject to ruſt than ſteel; the more this metal is divided, the more rapid is its alteration by expoſure to air. In this manner the preparation, known in pharmacy under the name of *aperitive ſaffron of Mars*, is prepared. Steel filings are expoſed to the air, and moiſtened with water, by which means they very quickly ruſt. The ſame proceſs with iron in the ſtate of *Æthiops*, or black oxyd, is ſtill more expeditious. In this alteration the metal is agglutinated, and forms maſſes which muſt be levigated before they can be employed in medicine. It was formerly thought that the ruſt of iron was produced by the air, but it is at preſent known, that this metal is calcined by water. My own experiments lead me to think, that the *aperitive ſaffron of Mars* is a combination of the oxyd of iron with the carbonic acid. I have diſtilled the *ſaffron of Mars* in the pneumato-chemical apparatus, and obtained a large quantity of this acid. The iron was changed into a black powder, ſtrongly attracted by the magnet. Joſſe, apothecary at Paris, has communicated to the Royal Society of Medicine, a like proceſs for quickly obtaining the *martial Æthiops*. He recommends igniting the *aperitive ſaffron of Mars* in a retort, to which a receiver, pierced with a ſmall hole, is adapted without luting; by this means the heat diſengages the carbonic acid, which Joſſe ſuffers to eſcape by the opening in the retort, and the iron remains in the ſtate of a black oxyd in powder, or of a *martial Æthiops*. I have often cauſed the cauſtic potaſh and ſoda to cryſtallize by this means; the inſide of the receiver being previouſly moiſtened with a ſolution of theſe ſalts: for the carbonic acid of the iron, uniting with the one or other of theſe alkalis, forms the neutral ſalts, which are called carbonats of potaſh or of ſoda. I have made many other experiments on the ruſt of iron, which are explained in one of my memoirs (*Memoires et Obſervations de Chemie* 1784), and various experiments have convinced me, that this matter is a true neutral ſalt, formed of the oxyd of iron and carbonic acid; for which reaſon I have given it the name of carbonat of iron, to diſtinguiſh it from the true oxyds of this metal. This ſalt is abſolutely the ſame with that which Bergman calls *aerated iron.* This theory poſſeſſes the advantage of having been adopted by Macquer, and perfectly explains the cauſe why iron ruſts very quickly in a humid and impure air; why it becomes ruſted ſo quickly, and to ſuch a depth, in places where the air is vitiated by the reſpiration of animals, by combuſtion, by animal vapours, and in ſtables, neceſſary houſes, &c. Iron is the moſt alterable, by contact of air, of all metallic ſubſtances; and this alteration is not confined to its ſurface; bars of iron of conſiderable thickneſs are often found to be ruſted quite to the middle.

Cold water has a conſiderable action on iron, dividing it, and even diſſolving a part, according to the experiments of Monnet[d]; the purer the iron, and the more air the water contains, the larger is the quantity taken up. When iron filings have been agitated for ſome time in water, the metal appears to be extremely divided, and the turbid water, after decantation, depoſits a very black and ſubtle powder, called the *martial Æthiops* of Lemery. This powder muſt be carefully dried in a cloſe veſſel, by a mild heat, leſt the contact of the air ſhould ruſt it. The martial Æthiops is ſtrongly attracted by the magnet. It is a black oxyd of iron by water. As this operation is very long and delicate, many chemiſts have endeavoured to render it more eaſy in the practice. Rouelle employed the *mouſſoirs de la Garaye* for this preparation, and obtained a very fine *Æthiops* in much leſs time than the proceſs of Lemery requires to afford it. I think that the proceſs of Joſſe, which is much more expeditious, may be advantageouſly ſubſtituted; and ſeveral other proceſſes for preparing *Æthiops martial* are related in the following pages. The preparation of Lemery is owing to a true decompoſition of the water; hydrogen gas is diſengaged, and the iron becomes oxygenated by abſorbing 25 per cent. of oxygen. We ſhall immediately proceed to treat more at large of this oxydation of iron by water.

Bars of ſteel heated, and ſuddenly plunged in cold water, acquire a very conſiderable degree of hardneſs, and become brittle; theſe qualities are ſo much the more eminent, in proportion as the ſteel was hotter, and the fluid in which it is plunged, colder. This operation is called *tempering*. The degrees of hardneſs of ſteel may be varied at pleaſure; and it may likewiſe be eaſily deprived of its hardneſs, by heating it to the ſame degree it had before the tempering, and ſuffering it to cool gradually. This effect of the water appears to conſiſt in a change in the diſpoſition of the parts of the ſteel produced by the ſudden cooling, which impedes its cryſtallization. All metals are capable of acquiring hardneſs by the ſame proceſs. But this quality is the more ſenſible, in proportion as the metal is leſs fuſible; a property which iron poſſeſſes in a very low degree.

It has been diſcovered that a ſtrong action is exerted between water and iron. Lavoiſier having expoſed iron with water in a glaſs veſſel, over mercury, obſerved, that the iron became ruſty, and the water was diminiſhed in proportion as the elaſtic fluid was diſengaged, which filled the ſuperior part of the apparatus. This fluid was *inflammable* gas; the iron had increaſed in weight, and was oxydated. Lavoiſier ſuſpected that the water contained oxygen, and that this ſubſtance being united to the iron, the *inflammable* gas, or other principle of the water, was diſengaged in the ſame proportion. He afterwards made the experiment, in conjunction with Meuſnier, in a more decided manner, by introducing the vapour of water into a red hot gun barrel; he obtained a large quantity of *inflammable* gas; the inner part of the gun barrel became increaſed in bulk, and aſſumed a black, brittle, lamellated appearance, ſimilar to the iron ore of the Iſland of Elba. The metal was increaſed in weight, and the addition, together with the weight of *inflammable* gas, correſponded perfectly with that of the quantity of water deſtroyed. The portion of iron oxydated in this experiment was found ſeparate from that which had not ſuſtained the ſame alteration; it formed an interior cylinder, thicker, and of a texture, colour, conſiſtence, and form, very different from that of the external part. The heat of red hot iron is neceſſary, in order that this experiment ſhould ſucceed, becauſe this degree of heat ſingularly favours the ſeparation of the principles of the water by the metal; for which reaſon, when the gun barrel is not well ignited, and the water does not paſs in a ſtrongly elaſtic ſtate, *inflammable* gas is not diſengaged, the water not being decompoſed; a want of attention to this circumſtance has cauſed ſeveral philoſophers, who did not ſufficiently heat the iron, and introduced liquid water, to deny the decompoſition of that fluid, though its analyſis, accurately made by this experiment, is confirmed by the ſyntheſis, as Mongez and Lavoiſier have demonſtrated. There are many other circumſtances in which water is thus ſeparated into its principles, and contributes to the production of many very important phenomena, as will be hereafter explained. Of this kind is the experiment which has ſhown that water is a compound of 0,14 of hydrogen, and 0,86 of oxygen.

Iron, in its metallic ſtate, does not unite to earthy and ſtony matters; but the oxyd of iron facilitates the vitrification of all ſorts of ſtones, and colours them either green or brown. The colour communicated by the oxyds of iron are exceedingly various, according to the peculiar ſtate of the oxyd which approaches more or leſs to the metallic ſtate. Theſe oxyds have likewiſe the property of affording various degrees of conſiſtence to earths, with which nature or art has mixed them, by the aſſiſtance of water.

Barytes, magneſia, and lime, have no evident action on iron.

The pure fixed alkalis, and ammoniac, when diſſolved in water, act ſenſibly on this metal: after ſeveral days digeſtion the fluids become turbid, and afford a ſmall quantity of *Æthiops*, or black oxyd of iron, which falls down; a certain quantity of hydrogen gas being at the ſame time diſengaged, as the chemiſts of Dijon have obſerved. This circumſtance proves, that water contributes greatly to the effect. This fluid being decompoſed, affords the gas; and its decompoſition is favoured by alkalis.

Iron is ſoluble in all the acids. Monnet has obſerved, that concentrated ſulphuric acid does not act on this metal, unleſs it be boiling. When this mixture is diſtilled to dryneſs, the retort is found to contain flowers of ſulphur ſublimed, and a white maſs of ſulphat of iron, partly ſoluble in water, which, however, does not afford cryſtals, becauſe it has been decompoſed by heat. If this acid, diluted with two parts of water, be poured on iron filings, it diſſolves the metal very readily, without the aſſiſtance of heat. The ſolution is attended with the diſengagement of a large quantity of hydrogen gas, which may be made to detonate with a conſiderable noiſe, by applying a lighted candle to the aperture of the veſſel, after having cloſed it for a ſhort time with the hand. This gas burns with a reddiſh flame, and very often exhibits ſmall ſparkles, ſimilar to thoſe of iron filings. Macquer, Bergman, and Kirwan, think, that the ſulphuric acid in this combination diſengaged a large quantity of phlogiſton from the iron, and that the *inflammable* gas was derived entirely from the metal. This opinion appears to be founded on a circumſtance formerly believed, viz.

that *inflammable* gas might be extracted from iron alone, without addition, by the ſimple action of heat; but it is now proved, that iron does not afford hydrogen gas by heat, but in proportion to the water or the moiſture which may be preſent; and it is equally proved, that the water added to the ſulphuric acid in the preſent experiment, is the only ſubſtance which produces the hydrogen gas by its decompoſition. 1. Becauſe the ſulphuric acid, in a concentrated ſtate, affords only ſulphureous gas. 2. In the concentrated ſtate it does not attack iron without difficulty, and by the aſſiſtance of heat. 3. As ſoon as water is added, the action becomes much more rapid, and the production of hydrogen gas takes place. 4. The quantity of concentrated ſulphuric acid employed, is partly decompoſed by the iron when water is not added; whereas the acid entirely combines with the oxyd of iron, without ſuffering any decompoſition when water is added to the ſolution. This fact is proved, becauſe the ſame quantity of alkali is required to ſaturate the acid after its action on the iron, as it would have required before. It is therefore the water which oxydates the iron in this operation, as La Place long ſince ſuſpected, and Lavoiſier and Meuſnier have proved[e].

In proportion as the diluted ſulphuric acid acts on the iron, a portion of the metal is precipitated in a black powder, which Stahl ſuppoſed to be ſulphur, but Monnet found, on examination, to be *martial Æthiops*. This portion of black oxyd of iron, ſuperabundant to the ſaturation, frequently contains carbure of iron. When one part of the iron is combined with one part of the acid, though the latter be far from ſaturation, the ſolution ceaſes, and the metal is no longer acted on. Monnet, who made this obſervation, remarks, that when water is poured on the mixture, the action of the acid commences again; a phenomenon which ariſes from the water of the ſulphuric acid being abſorbed by the ſulphat of iron already formed; and the portion of the acid, which is not yet ſaturated, having no power to act on the iron, till a new quantity of water begins the oxydation of that metal. The ſulphuric acid diſſolves more than half its weight of iron, and the ſolution filtered and evaporated, affords, by cooling, a tranſparent ſalt, of a beautiful green colour, cryſtallized in rhomboids, called *martial vitriol*, or *green copperas*; we term it ſulphat of iron.

This ſalt is not made in the direct way, becauſe it is abundantly afforded by nature, and is eaſily extracted by art from *martial pyrites.* Theſe ſulphures being expoſed to air for a certain time, are decompoſed by moiſture; a white efflorescence appearing on their ſurface, which, by ſolution in water and cryſtallization, is found to be ſulphat of iron. This decompoſition of pyrites, according to Stahl, depends on double affinities. Sulphur (ſays he), a compound of *phlogiſton*, and the *vitriolic acid*, is not decompoſable by water, nor by iron alone; but when theſe ſubſtances are united, the iron ſeizes the phlogiſton of the ſulphur, its acid uniting to the water, and diſſolving the metal. The pyrites, which are the leaſt ſuſceptible of efflorefcence, as for example, thoſe which are the moſt brilliant, being roaſted to drive off a portion of the ſulphur they contain, and afterwards expoſed to the air, readily effloreſce. The *vitriol* is ſeparated by waſhing, and the ſolution of this ſalt immediately depoſits a certain quantity of iron, in the ſtate of ochre, for which reaſon the fluid is not evaporated, for the purpoſe of obtaining cryſtals, till this precipitate has fallen. Modern chemiſts have proved, that in the effloreſcence of the pyrites, the ſulphur which is divided as in its combinations with alkaline ſubſtances, combines with a portion of oxygen, and forms ſulphuric acid, which, being diluted by the water of the atmoſphere, unites with heat to the iron, and diſſolves it. The neceſſity of the contact of air for the effloreſcence of pyrites, gives much force to this opinion; and the moiſture, which greatly favours the *vitriolization*, acts in this caſe as it does in the ſolution of iron; this is the cauſe of the hydrogen gas which is diſengaged when the operation is made in a vacuum.

Sulphat of iron is of an emerald green colour, and has a very ſtrong aſtringent taſte; it ſometimes reddens ſyrup of violets, but this effect is not conſtant; its cryſtals contain, according to Kunckel and Monnet, more than half their weight of water; if it be heated briſkly, it liquifies like all ſalts, which are more ſoluble in hot than in cold water; it becomes of a whitiſh grey by drying; if it be heated by a more violent fire, a portion of its acid eſcapes under the form of ſulphureous gas, and the ſalt aſſumes a red colour, in which ſtate it is named *colcothar.* Sulphat of iron, calcined to redneſs, attracts the humidity of the air very ſenſibly, on account of a portion of ſulphuric acid it contains. Diſtilled in a retort placed in a reverberatory furnace, this ſalt affords firſt, water ſlightly acid, called *dew* of *vitriol.* The receiver is to be changed, in order to obtain ſeparately the concentrated ſulphuric acid, which, when the heat is very ſtrong, paſſes over of a black colour, and exhaling a ſuffocating ſmell of volatile ſulphureous acid. Theſe characters depend on its being deprived of a part of its oxygen, which is fixed in the iron, according to the doctrine of the gaſes; towards the end of the operation, the acid which comes over takes a concrete and cryſtalline form, and is diſtinguiſhed by the name of *glacial ſulphuric acid.* This experiment, deſcribed by Hellot, did not ſucceed with Baumé, though it is admitted as certain by moſt chemiſts. When glacial ſulphuric acid is diſtilled in a ſmall retort, it gives out ſulphureous gas, and comes over white and fluid; its concrete ſtate is therefore owing to the preſence of this gas; it unites with water with noiſe and heat, ſulphureous gas being at the ſame time diſengaged. The *fuming oil of vitriol of Noorthauſſen* is of this kind, and the concrete ſalt obtained from it by a gentle heat, of which I have given an analyſis in a memoir publiſhed among thoſe of the Academy for the year 1785.

The reſidue of ſulphat of iron, after diſtillation, is red, and ſimilar to colcothar. When waſhed with water, a white ſalt little known, and named *ſalt of colcothar*, or *fixed ſalt of vitriol*, is ſeparated; a red inſipid earth, which is a pure oxyd of iron, and is called *ſweet earth of vitriol*, remains behind.

Sulphat of iron expoſed to the air becomes yellowiſh, and covered with ruſt; oxygen being gradually abſorbed, oxydates the iron more and more, ſo that it cannot remain united with the ſulphuric acid. The ſolution of this ſalt exhibits the ſame phenomenon, by the contact of the atmoſphere, and both may ſerve the purpoſe of an eudiometer. This ſalt is ſoluble in twice its weight in cold, or in a leſs quantity of hot water; but as ſoon as the water is ſaturated, it appears turbid, by a more or leſs conſiderable quantity of ochre which ſeparates; the fluid being filtered, and ſuffered to cool, affords rhomboidal cryſtals, of a pale tranſparent green; the remaining fluid being again evaporated, affords a new quantity of cryſtals by cooling; and when all the cryſtals have been obtained, that the ſolution is capable of affording, a mother water, of a blackiſh green, or brown yellow, remains, which is no longer capable of cryſtallizing; this being evaporated by a ſtrong heat, and ſuffered to cool, appears to be a ſoft unctuous maſs, ſtrongly attracting the humidity of the air; when evaporated to dryneſs, it affords a greeniſh yellow powder. According to Monnet, the mother water of ſulphat of iron contains iron in the ſtate of a perfect oxyd: this chemiſt aſcertained the fact, by immediately diſſolving, with the aſſiſtance of heat, a true oxyd of iron in this acid; the ſolution was brown, and incapable of cryſtallizing.

The oxyd of iron may be ſeparated from the mother water, not only by the earth of alum, but likewiſe by copper and iron filings, which does not happen to perfect ſulphat of iron. A well charged ſolution of this ſalt being expoſed to the air, is converted, after a certain time, into mother water, ſimilar to the foregoing, by attracting the oxygen of the atmoſphere [f].

Sulphat of iron is decompoſed by lime and alkalies: lime-water poured into a ſolution of this ſalt, forms a precipitate in flocks, of a deep olive green; a portion of this precipitate is rediſſolved in the lime water, and communicates to it a reddiſh colour. I have communicated two Memoirs to the Academy, in the years 1777 and 1778, concerning the precipitates of iron obtained by cauſtic and non-cauſtic alkalis, in which I have carefully deſcribed the phenomena of their precipitations, and the ſtate of the iron in the different circumſtances. I ſhall here relate the principal circumſtances relative to ſulphat of iron. Cauſtic fixed alkali precipitates the ſulphuric ſolution of iron in flocks of a deep green, which are diſſolved again, in ſome meaſure, by the alkali, and form a kind of martial tincture, of a beautiful red; when leſs of the alkali is added, the precipitate may be collected, and a blackiſh *Æthiops*, or black oxyd of iron, is obtained, if it be dried quickly in cloſed veſſels. Without theſe two precautions, the iron quickly becomes oxydated, becauſe it is very much divided and moiſt. Potaſh, ſaturated with the carbonic acid, or the carbonat of potaſh, forms a precipitate of a greeniſh white colour, not ſoluble in the alkali; this difference ariſes from the preſence of the carbonic acid, which ſeizes the iron, in proportion as it is itſelf ſeparated from the alkali by the ſulphuric acid; the pure or cauſtic ammoniac ſeparates from the ſolution of ſulphat of iron a precipitate of ſo deep a green, that it appears black; it is not ſoluble in the ammoniac. By ſudden drying, without the contact of the air, it may be obtained black, and obedient to the magnet. The precipitate formed by concrete ammoniac, or ammoniacal carbonat, is of a greeniſh grey: it is partly rediſſolved in this ſalt, and communicates a red colour; an event ſimilar to what happens when the precipitations are made by fixed alkali. The fixed alkali diſſolves only a ſmall portion of the precipitated iron, but a well ſaturated carbonat of potaſh diſſolves it readily.

Vegetable aſtringent matters, ſuch as nut-galls, ſumac, rind of pomegranates, huſks of nuts, quinquina, cypreſs nuts, logwood, tea, &c. have the property of precipitating ſulphat of a black colour: this precipitate, which cannot be miſtaken for iron, is ſo extremely divided, that it remains ſuſpended in the fluid; the addition of gum arabic to the mixture, cauſes the iron to be permanently ſuſpended, and forms a black fluid, known by the name of *ink*. It is not well decided what happens during this experiment. Macquer, Monnet, and moſt chemiſts, conſider the precipitate of ink as iron united to a principle of the nut-gall, which diſengages it from the acid; they ſeem to think that this principle is an oily ſtate. Gioanetti, phyſician at Turin, has made many experiments on iron precipitated from its ſolutions by aſtringents. Theſe inquiries, which are to be found in his Analyſis of the Waters of St. Vincent, ſhow, that the precipitate is not attracted by the loadſtone; that it becomes attractable by heating in a well cloſed veſſel; that it is ſoluble in acids, without efferveſcence; that theſe ſolutions do not become black on the addition of freſh galls, which ſhows that the iron is united to the aſtringent principle, and is in the ſtate of a kind of neutral ſalt. In the third volume of the Elements of Chemiſtry of the Academy of Dijon, there is a ſeries of experiments on the vegetable aſtringent principle, which ſeem to aſſimilate this ſubſtance to acids; in fact, it reddens blue vegetable colours, unites to alkalis, decompoſes alkaline or earthy ſulphure, diſſolves and appears to neutralize metals, decompoſes all metallic ſolutions with particular phenomena; riſes in diſtillation without being deprived of its action on metals, and preſents a great number of other properties, concerning which, the order we have adopted will not permit us to enlarge.

This inquiry of the academicians of Dijon has been confirmed by the reſearches of Scheele. This celebrated chemiſt has diſcovered, that a ſimple infuſion of nut-galls in water affords by ſeparation a peculiar cryſtallizable acid, which takes iron from many other acids, and colours it black, becauſe it approaches to the metallic ſtate. We call this ſalt the *gallic acid*, and ſhall give an account of it in the hiſtory of the vegetable kingdom.

The decompoſition of ſulphat of iron, by an alkali calcined with bullock's blood, is a phenomenon ſtill more difficult to be underſtood than the action of the nut-gall on this ſalt; the precipitate obtained is of a beautiful blue colour, and inſoluble in acids. This precipitate is called *Pruſſian* or *Berlin blue*, from the place of its diſcovery. Stahl reports, that a chemiſt named Dieſbach, having borrowed ſome fixed alkali from Dippel, to precipitate a ſolution of cochineal, mixed with a ſmall quantity of alum and ſulphat of iron, the latter gave him an alkali from which he had diſtilled his animal oil; the ſalt precipitated the ſolution of Dieſbach of a blue colour. Dippel examined the cauſe of this precipitate, and by a leſs complicated proceſs, prepared the Pruſſian blue, which was mentioned in the year 1710, in the publication of the Academy of Berlin, but without any detail reſpecting the operations. Several chemiſts laboured earneſtly to produce the ſame, and ſucceeded. But it was not till the year 1724, that Woodward publiſhed, in the Philoſophical Tranſactions, a proceſs for preparing this colouring ſubſtance.

To form Pruſſian blue, four ounces of *nitre fixed by tartar* are mixed with an equal weight of dried ox's blood; this mixture is calcined in a crucible till it reſembles coal, and no longer produces any flame; a ſufficient quantity of water is then added to diſſolve all the ſaline matter, which is called *phlogiſticated alkali*, or *colouring lixivium*, and is concentrated by evaporation;

two ounces of ſulphat of iron, and four ounces of ſulphat of alumine, are afterwards diſſolved in a pint of water; the ſolution of theſe ſalts is mixed with the alkaline lixivium, a greeniſh precipitate falls down, which is ſeparated by the filter, and muriatic acid being poured on it, it immediately becomes of a more beautiful and deeper blue, and is to be then dried by a mild heat, or by expoſure to the air.

Many chemiſts have, ſince the time of Woodward, attended to the theory and preparation of Pruſſian blue. With regard to its preparation, it is now known that a great number of ſubſtances are capable of communicating to the alkali the property of precipitating iron of a blue colour.

Geoffroy, in the Memoirs of the Academy for the year 1725, communicated this property to alkalis with all kinds of animal coals. Baumé affirms, that the *phlogiſticated alkali* may likewiſe be prepared by the coals of vegetable ſubſtances, provided a ſtronger heat be uſed. Spielman made it with bitumens, and Brandt with ſoot. The manufactories of Pruſſian blue are become numerous, and each, as it ſeems, uſe different matters for their preparation. M. Baunach informs us, that in Germany, the nails, horn, and ſkins of oxen are uſed. All animal matters do not, however, appear proper to phlogiſticate the alkali; they have in vain attempted to prepare it with the gall of the ox, by a proceſs ſimilar to that which is executed with the blood. I obtained only an alkali, with precipitated vitriol of a greeniſh white, and the precipitate was entirely ſoluble in muriatic acid.

Chemiſts have differed greatly on the theory of Pruſſian blue. Brown and Geoffroy conſidered it as the *phlogiſtic* part of iron, developed by the lixivium of blood, and transferred to the earth of alum: the Abbé Menon imagined that it was the pureſt iron, diſengaged from every foreign ſubſtance by the *phlogiſticated* alkali: Macquer, in a Memoir which has juſtly deſerved the name of Maſterpiece from every chemiſt, and is inſerted in the Memoirs of the Academy for the year 1752, has refuted the opinions of theſe authors; he thinks the Pruſſian blue conſiſts of iron, combined with an exceſs of the inflammable principle afforded by the *phlogiſticated* alkali, which this laſt obtained from the blood. He obſerves, 1. That Pruſſian blue, expoſed to the fire, loſes its colour, and becomes ſimple iron. 2. That this blue is not at all ſoluble in acids, however ſtrong. 3. That alkalis are capable of diſſolving the colouring matter of Pruſſian blue, and of becoming ſaturated therewith: for this purpoſe, an alkaline lixivium is to be heated on Pruſſian blue, till it ceaſes to diſcolour that pigment. This alkali, ſaturated with the colouring matter of Pruſſian blue, is found to be deprived of moſt of its properties; it is no longer cauſtic nor effervescent with acids; among the earthy ſalts it decompoſes only the barytic; it precipitates all metallic ſalts, and it ſeems that this decompoſition takes place by virtue of a double affinity, that of the acid on the alkali, and that of the metallic oxyd on the colouring matter united to the ſalt. An alkali, in this manner, is capable of diſcolouring the twentieth of its weight of Pruſſian blue, and is then ſaturated with the colouring matter; acids diſengage a ſmall quantity of blue fecula from it, and it immediately precipitates ſulphat of iron in the form of perfect Pruſſian blue.

With regard to the alkali prepared in the uſual way, Macquer obſerves, that it is very far from being entirely ſaturated with colouring matter; and that, on this account, it firſt precipitates the ſolution of ſulphat of iron of a green colour: in fact, it is the portion of alkali which is ſaturated that precipitates the iron of a blue colour; but the portion which is not ſaturated precipitates the iron in the ſtate of ochre, which renders the blue precipitate green by the mixture of this laſt colour with yellow. In this ingenious theory, the acid poured on the precipitate ſerves to diſſolve the portion which is not in the ſtate of Pruſſian blue, and conſequently renders the colour of this laſt more intenſe; the alum added to the ſolution of ſulphat of iron ſaturates the alkali, which is not charged with colouring matter, and the earth of this ſalt, depoſited with the Pruſſian blue, renders it leſs deep. As it is neceſſary to pour an acid on the precipitate of ſulphat of iron, in order to render the Pruſſian blue more lively; this acid may be added to the alkali before it is uſed to precipitate the iron, in which caſe, the acid ſaturating the portion of pure alkali does not unite to that which is charged with the colouring matter, and therefore leaves it capable of inſtantly forming a fine Pruſſian blue. This alkali, partly *phlogiſticated* by bullock's blood, may be fully ſaturated by digeſting it on Pruſſian blue, till it ceaſes to deprive it of its colour. Macquer obſerved, that this alkali ſaturated with acid, is a good teſt to diſcover the preſence of iron in mineral waters; but Baumé has remarked, that the liquor itſelf contains a certain quantity of Pruſſian blue, which might be productive of error: he therefore propoſes to digeſt it for a ſufficient time in a mild heat, with a ſmall quantity of vinegar, that it may depoſit all the blue matter it contains.

Such was the admirable ſeries of experiments made by Macquer on the Pruſſian blue; but this celebrated chemiſt was himſelf ſenſible how much remained to be done, eſpecially with reſpect to the nature of the colouring ſubſtance: he could not be perſuaded that it was pure phlogiſton, becauſe on that ſuppoſition it was difficult to determine how the iron, overcharged with that principle, became deprived of the property of obeying the magnet, and of ſolubility in acids, which, according to Stahl, are conſequences of the preſence of phlogiſton in this metal. Morveau is the firſt, who, in his excellent Diſſertation on Phlogiſton, has attempted to diſcover the nature of the colouring part of Pruſſian blue. From two drachms of this compound he obtained by diſtillation twenty-two grains of a yellow empyreumatic liquor, which cauſed an efferveſcence with alkaline carbonats, ſtrongly reddened blue paper, and of which Geoffroy and Macquer, who likewiſe diſtilled Pruſſian blue, have made no mention.

Sage, in the year 1772, communicated to the Electoral Academy of Mentz, a Memoir on the *phlogiſticated alkali*, which he calls animal ſalt. The lixivium of the fixed alkali treated with blood, and digeſted on the Pruſſian blue, according to the manner of Macquer, is, as Sage affirms, a neutral ſalt, formed by the animal acid and fixed alkali, and affords, by ſpontaneous evaporation, cryſtals which are either cubical, octahedral, or quadrangular priſms, terminated by four-ſided pyramids. This ſalt decrepitates on charcoal, melts by a violent fire into a ſemitranſparent maſs, ſoluble in water, and proper to form Pruſſian blue. Sage thinks, that the acid which neutralizes the alkali in this ſalt, is the phoſphoric, becauſe when a mixture of alkali and bullock's blood are ſtrongly heated, it melts and emits acrid vapours, accompanied with white and brilliant ſparks, which, according to him, are burning phoſphorus. This opinion reſpecting the acid of the Pruſſian alkali would be proved, if, on the one ſide, phoſphorus were obtained by diſtillation with charcoal, which likewiſe would take place with reſpect to the Pruſſian blue; and if, on the other ſide, Pruſſian blue could be formed by combining phoſphat of ſoda, or of potaſh, with a ſolution of iron: but as Sage has not related any experiments of this nature in his Memoir, his theory cannot be admitted.

The chemiſts of the Academy of Dijon have adopted part of this laſt doctrine: in their Elements they conſider the phlogiſticated lixivium as a ſolution of a neutral ſalt; they adviſe the cryſtallizing it by evaporation, inſtead of purifying it by vinegar, as Baumé propoſed. This ſalt is very pure according to them, and cauſes a detonation when thrown on nitre in fuſion: they have ſaid nothing concerning its decompoſitions, and the nature of its principles; they call it the cryſtallized Pruſſian alkali.

Bucquet having precipitated by the muriatic acid, and filtered a lixivium prepared for Pruſſian blue, obſerved that this alkali, though very clear, and apparently deprived of all the Pruſſian blue it might contain, nevertheleſs depoſited a blue powder. After having filtered it more than twenty times in the ſpace of two years, to ſeparate the Pruſſian blue which was depoſited after each filtration, he at laſt found that the liquor was no longer capable of affording Pruſſian blue with the ſolution of ſulphat of iron. I have ſtill by me a ſmall portion of this lixivium, which has been prepared for near eight years: it is two years ſince it has depoſited any precipitate, but it has depoſited a light blueiſh covering on the ſides of the glaſs in which it is contained, and has itſelf preſerved a ſimilar colour. I have had occaſion twice to obſerve this phenomenon ſince I firſt heard it mentioned by Bucquet in his lectures, and I think it is conſtant. The Duke de Chaulnes ſhowed Macquer a colouring lixivium, which did not afford Pruſſian blue when previouſly mixed with an acid. This chemiſt ſuppoſes that it ariſes from its having been prepared in metallic veſſels. From the obſervation before recited, Bucquet ſuppoſed, 1. That the Pruſſian blue is entirely contained in the alkali, which ſerves to precipitate it. 2. That acids alone are ſufficient to ſeparate it from the alkali. 3. That when this alkali, at the end of a certain time, has depoſited all the colouring matter it contains, it is no longer proper to form Pruſſian blue.

The *Journal de Phyſique* for the year 1778 contains obſervations on Pruſſian blue, by M. Baunach, apothecary at Metz, which greatly favour the opinion of Bucquet. After having deſcribed the proceſs employed in the manufactories in Germany to prepare Pruſſian blue, M. Baunach affirms, that the lixivium made in theſe manufactories by the fuſion of alkali, and of the hoofs, horns, and ſkins of oxen, precipitates all the metals, and even calcareous earth, of a blue colour. This alkali diſſolves the metals after having precipitated them, and they may be ſeparated of a very beautiful blue colour by the muriatic acid. The ſingular facts related in this memoir, ſuch as the diſtillation of Pruſſian blue produced by this lixivium, which affords neither oil nor ammoniac; the ſolubility of the blue precipitate (formed by the muriatic acid poured on this lixivium) in the nitric acid; the calcareous earth found in ſolution in the latter acid, which diſcoloured the blue; a peculiar and phlogiſticated earth which he did not ſucceed in diſſolving; do not theſe circumſtances prove that this blue is not of the ſame nature with that which is precipitated from the common phlogiſticated lixivium in which Macquer diſcovered iron that could only come from the blood?

Since theſe various inquiries into the nature of Pruſſian blue, Scheele has made a number of new reſearches, which, together with certain obſervations not yet mentioned, tend greatly to elucidate the nature of this production.

1. The Pruſſian blue of commerce, diſtilled with a naked fire, affords a very large quantity of hydrogen gas, together with oil, ammoniacal carbonat, and a ſmall quantity of acid phlegm. This gas burns blue like the inflammable air of marſhes; its ſmell is empyreumatic; lime water gives it the property of burning with a red colour, and of detonating with vital air, becauſe it abſorbs a portion of the carbonic acid with which it was united. Laſſone conſidered the gas of Pruſſian blue as a peculiar inflammable gas. Pruſſian blue, after this analyſis, has the form of a blackiſh powder, obedient to the

magnet. Before it takes this colour, it is of an orange colour, as Morveau has obſerved: the laſt mentioned chemiſt even thought that Pruſſian blue, after it has been converted to an orange colour by heat, might be uſeful as a pigment.

2. Ammoniac heated on Pruſſian blue decompoſes it, by ſeizing its colouring matter, and leaves the iron in the ſtate of a brown oxyd. Macquer announced this fact in the year 1752. Meyer, who ſucceeded him, gave the name of *tinging* liquor to this volatile alkali, ſaturated with the colouring part of the blue, and adviſes the uſe of it in the analyſis of mineral waters. I have obſerved, that when the cauſtic ammoniac is diſtilled from Pruſſian blue, the fluid which paſſes over has not the property of giving a blue colour to the ſolutions of iron, whence it follows, that the colouring principle is not as volatile as the ammoniac. When a portion only of this ſalt is diſtilled over, the reſidue is of an olive green; if this be diluted with diſtilled water and filtered, it is found to be charged with the colouring matter, and affords a very lively Pruſſian blue when added to ſulphat of iron.

3. In the year 1780, I diſcovered that lime water digeſted by a ſlight heat on Pruſſian blue diſſolves the colouring matter; the combination is quickly effected, the lime water being coloured, and the Pruſſian blue aſſuming a ruſty appearance; the lime water, after filtration, is of a beautiful clear yellow colour, no longer capable of converting ſyrup of violets to a green; no longer of an alkaline taſte, nor precipitable by the carbonic acid; it does not unite with other acids; and, in a word, it is neutralized by the Pruſſian colouring matter, and affords, when poured on the ſolution of ſulphat of iron, a very fine blue, which does not need an acid to enliven its colour. Scheele ſpeaks of this Pruſſian lime water doubtleſs without being previouſly acquainted with my experiments on the ſubject, though they were inſerted in my Elements of Chemiſtry, printed in the year 1781. He, as well as myſelf, conſiders this combination as the beſt of thoſe which have been propoſed as teſts of the preſence of iron, becauſe it does not contain any, or at leaſt only a very minute portion of Pruſſian blue ready formed.

4. Cauſtic fixed alkalis diſcolour the Pruſſian blue immedi-

ately in the cold. I have obſerved that a conſiderable heat is produced in theſe experiments; that the alkalis in a ſtate of purity diſcolour a much greater quantity of Pruſſian blue than thoſe which are ſaturated with carbonic acid, and that they precipitate a larger quantity of the blue with ſolutions of iron.

5. I found that magneſia has likewiſe the property of diſcolouring Pruſſian blue, though much more weakly than lime-water.

6. Pruſſian blue thrown in powder on melted nitre produces ſome ſparkles, which denote that it contains a combuſtible matter.

7. Pruſſian blue prepared without alum becomes ſtrongly attracted by the magnet by a ſlight calcination; but the Pruſſian blue of commerce never acquires that property by the action of fire.

8. Pruſſian blue diſcoloured by alkaline matters, and in the ſtate of oxyd of iron, reaſſumes a blue colour when an acid is added: this circumſtance ſeems to depend on the whole of the colouring matter not being taken away by the firſt action of the alkalis, and that a portion is defended by the external ſtratum of ferruginous oxyd.

All theſe facts ſhow that the colouring part of Pruſſian blue is a peculiar acid, which ſaturates alkalis, and forms neutral ſalts. This opinion is adopted by many chemiſts, and in particular by Scheele, whoſe reſearches on this matter only remain to be related. This celebrated chemiſt has proved by his experiments, 1. That a lixivium of blood, or phlogiſticated alkali, is decompoſed by the carbonic acid of the atmoſphere, and that all the other acids ſeparate the colouring matter. 2. That this colouring matter is fixed and retained in the lixivium by a ſmall quantity of iron, or of pure ſulphat of iron. 3. That when it is diſengaged by acids in diſtillation, it fills the receiver with a vapour, which precipitates the ſolutions of iron of a blue colour. 4. That Pruſſian blue diſtilled without addition, as well as the lixivium of blood, affords, together with the colouring matter, foreign products, which alter it, ſuch as ſulphur; and that the colouring matter cannot be had pure by this proceſs. 5. That Pruſſian alkalis diſtilled with the ſulphuric acid precipitate a large quantity of Pruſſian blue, and afford a liquor charged with the colouring matter. The portion of blue precipitated in this operation depends on the iron diſſolved in theſe triple ſalts, or combinations of alkalis, colouring matter, and iron. 6. That the oxyd of mercury or red precipitate ſeizes the colouring matter of Pruſſian blue, or pruſſiat of iron, by ebullition, in double their weight of water; and that if this mercurial Pruſſian lixivium be diſtilled with the addition of iron and ſulphuric acid, the iron reduces the mercury, and the acid diſengages the colouring matter; this laſt becoming diſſolved in the water of the receiver, in proportion as it is diſengaged, and retaining a portion of ſulphuric acid. To ſeparate them, Scheele mixes a ſmall quantity of chalk with the liquor, and diſtils by a gentle heat: the colouring matter paſſes over in a ſtate of great purity, and as it is diſengaged in the form of an elaſtic fluid, as Monge alſo obſerved, it may be received in water by the aſſiſtance of tubes, or the pneumato-chemical apparatus, which has already been often mentioned.

After theſe reſearches concerning the affinities of the colouring Pruſſian matter, its adherence with alkalis, and the method of obtaining it perfectly pure, Scheele, in a ſecond Memoir, inquires into the nature of this ſubſtance, and its combinations with alkalis and metallic oxyds; and though his experiments are numerous, and very accurate, he does not prove that the colouring matter is a peculiar acid; on the contrary, he proves that it contains inflammable gas, ammoniac, and a carbonaceous principle. He, however, has obſerved, that it poſſeſſes the property of coagulating ſoap, and precipitating *hepars;* and he calls it the colouring acid, in a letter to Crell. Morveau calls this ſubſtance by the name of Pruſſic acid, and diſtinguiſhes its ſaline combinations, according to his nomenclature, by the names of Pruſſiats; as, for example, pruſſiats of potaſh, of ſoda, of ammoniac, &c. In a note by the tranſlator of Scheele, it is aſſerted, that this acid is decompoſed by the acid of nitre; and a proceſs of Weſtrumb, to obtain the pruſſiat of potaſh in a ſtate of great purity, is given. It conſiſts in ſaturating cauſtic vegetable alkali with the colouring matter, digeſting it on *white lead,* to deprive it of the *hepatic gas* it may contain, mixing it with diſtilled vinegar, and expoſing it to the ſun, as

Scopoli and Father Bercia adviſed to precipitate the iron; after which two parts of rectified ſpirit of wine are added. The pruſſiat of potaſh is then depoſited in lamellated and brilliant flocks, which being waſhed in freſh ſpirit of wine, is afterwards dried, and diſſolved in diſtilled water. Scheele, three months after Weſtrumb, forwarded to Crell an analogous proceſs for obtaining a proof liquor, which might be depended on as a teſt of the preſence of iron.

Berthollet has made experiments upon the pruſſic acid, or colouring matter of Pruſſian blue, ſince all theſe chemiſts. Although the reſearches of this learned philoſopher have not yet proved entirely ſatisfactory to himſelf, they nevertheleſs contain facts and experiments of ſufficient novelty and importance to induce us to inſert, in this place, an extract of his Memoir, which he has had the goodneſs to communicate to us.

Berthollet, in the firſt place, diſtinguiſhes two kinds of pruſſiat of iron; the one which is the common Pruſſian blue, and the other which is the ſame Pruſſian blue deprived of a portion of the pruſſic acid. He calls this *pruſſiat of iron with exceſs of oxyd.* Pruſſian blue is in this laſt ſtate after it has been diſcoloured by an alkali. To ſeparate this exceſs of oxyd, he uſes the muriatic acid, which diſſolves it, and leaves the pruſſiat of iron neutral. He obſerves with Landriani, that, when the alkali is digeſted with heat upon the Pruſſian blue, the alkaline pruſſiat which is formed diſſolves more of the oxyd of this metal than when the digeſtion is made in the cold. Both theſe chemiſts think that an acid added to this triple combination unites to the exceſs of oxyd of the iron, and cauſes the Pruſſian blue to be depoſited in the ſame manner as when the pure pruſſiat of potaſh is added to a ſolution of iron. They add likewiſe, that heat cauſes a precipitate to fall down from this combination, which conſiſts of a yellow pruſſiat of iron, that is to ſay, with exceſs of oxyd of iron. According to them, the acid which is added ſeizes the exceſs of oxyd of iron, and ſuffers the precipitate of Pruſſian blue to fall down, which is then leſs ſoluble in the alkaline pruſſiat. When the pruſſiat of potaſh, prepared by a gentle heat, has depoſited the pruſſiat of iron, with exceſs of oxyd of this metal, by ebullition, it may be evaporated to dryneſs, rediſſolved in water, and mixed with acids, without depoſiting Pruſſian blue. Berthollet affirms, that, from the evaporation of the ſolution of pruſſiat of potaſh thus purified, octahedral cryſtals are obtained by evaporation, two of whoſe pyramids are truncated in ſuch a manner as to repreſent ſquare plates, whoſe edges are chamfered off[g].

This chemiſt having mixed a ſolution of theſe cryſtals with the ſulphuric acid, and expoſed the whole in a bottle to the rays of the ſun, ſaw, that a ſhort time afterwards a blue colour was developed, which formed a precipitate until its total decompoſition. A like mixture, preſerved in a dark place, did not become blue, nor afford a precipitate even at the end of ſeveral months: a ſtrong heat produces abſolutely the ſame effect. From theſe experiments, Berthollet ſhows on what inaccurate information the proceſſes recommended for purifying the alkaline pruſſiats were founded; for, ſaid he, they were decompoſed for the moſt part, inſtead of depriving them of a portion of Pruſſian blue, which chemiſts pretended was only accidentally mixed with it. As the pruſſiat of potaſh is a triple ſalt, the pruſſic acid has only a very ſlight adheſion to the potaſh, and is ſeparated by all the other acids. In proportion as the foreign acid unites to the potaſh, part of the pruſſic acid unites to the oxyd of iron, forming Pruſſian blue; and the other is volatilized in the ſtate of acid, or reduced to its principles.

The iron which is precipitated by the alkaline pruſſiats retains, according to Berthollet, a conſiderable portion of thoſe ſalts: it may be deprived of them by repeated waſhings. Theſe lixiviums contain the alkalis combined with a ſmall portion of pruſſic acid; and the pruſſiats, with exceſs of alkali, are not carried off until the exceſs of acid in the ſolution of iron is carried off by the firſt waſhings; for the latter lixiviums precipitate iron in the form of Pruſſian blue from its ſolutions, though the firſt do not.

He did not find any ſenſible difference between the pruſſiats of potaſh and of ſoda, excepting that the latter cryſtallizes differently: the mineral acids diſengage the pruſſic acid, partly fixed in the Pruſſian blue, which falls down; it is this which engaged Scheele to contrive another combination, from which he could obtain the pure acid with greater facility, and upon which Berthollet makes ſome obſervations. This proceſs conſiſts, as we have already obſerved, in boiling the red oxyd of mercury in diſtilled water, together with Pruſſian blue; the pruſſic acid quits the oxyd of iron to unite with the oxyd of mercury, with which it has a ſtronger attraction, and forms a ſoluble ſalt, which cryſtallizes in tetrahedral priſms, terminated by quadrangular pyramids, whoſe planes anſwer to the angles of the priſm. Iron and concentrated ſulphuric acid are added to the filtrated lixivium; the iron unites with the oxygen of the mercury, and combines with the ſulphuric acid; the mercury falls down with its metallic brilliancy. Scheele afterwards diſtilled this mixture with a gentle heat, in order to volatilize only the pruſſic acid; but he found, that however ſlight the heat was, it always paſſed, mixed with a ſmall quantity of ſulphuric acid. To obviate this difficulty, he added a certain quantity of chalk to fix the ſulphuric acid. Upon this addition, Berthollet takes notice, that, as Scheele did not ſpecify the doſe of this ſubſtance, it was very eaſy to fail in the operation, if the chalk exceeded a little the point of ſaturation of the ſulphuric acid; for calcareous pruſſiat would then be formed, which, by the law of double affinities, would decompoſe the ſulphat of iron.

Berthollet found that the ſulphuric acid diſengaged only a ſmall quantity of acid from the pruſſiat of mercury; that it united, for the moſt part, with this ſalt, without decompoſing it, and formed a triple ſalt, cryſtallizing in ſmall needles. According to his experiments, the muriatic acid diſengages more acid from the pruſſiat of mercury than the foregoing, and equally forms a triple ſalt, capable of cryſtallizing in needles, and much more ſoluble than the corroſive mercurial muriat. Alkalis and lime precipitate this triple ſalt of a white appearance. Berthollet proves that the alkaline pruſſiats do not precipitate barytes from its ſolutions, as Bergman had thought, but that they form triple ſalts. He ſhows that they precipitate alumine. The precipitate they form with this ſubſtance is not altered by the ſulphuric acid; but, digeſted with the ſulphat of iron, it forms Pruſſian blue.

The pruſſic acid decompoſes the oxygenated muriatic acid, abſorbs its oxygen, and becomes fragrant. In this ſtate it does not appear to have a great tendency to alkaline ſubſtances; for they ſcarcely diminiſh its ſmell. It does not precipitate iron of a blue, but of a green colour; and this green precipitate is ſoluble in acids. It becomes blue by the contact of the ſun's rays, as well as by the addition of the ſulphureous acid and iron. The ſame phenomena happen when the oxygenated muriatic acid, ſulphat of iron, and pruſſiat of potaſh, are mixed together. Hence Berthollet thinks that Pruſſian blue is not alterable by light and by the ſulphureous acid, and that it is to the abſorption of oxygen that it owes its green colour, its ſolubility in acids, &c.

If the pruſſic acid be ſurcharged with oxygenated muriatic acid, and afterwards expoſed to the luminous rays, it aſſumes new characters; it no longer combines with the oxyd of iron nor with water, at the bottom of which it flows in the form of oil, and with an aromatic odour. If in this ſtate more oxygen be added, and it be left in the ſun, it cryſtallizes in the form of ſmall white needles. This acid, thus oxygenated, is reduced into vapours at a gentle temperature: theſe vapours are not ſoluble in water, and nevertheleſs are not combuſtible. Berthollet has not yet been able to determine what paſſes in this operation. Does the pruſſic acid ſimply unite with oxygen without alteration, or is one of its principles burned? We ſhall more willingly adopt this laſt idea with him, for though the oxygen appears to be only ſlightly adherent to the pruſſic acid, it can no longer be reſtored when it has been thus treated with oxygenated muriatic acid.

When the pruſſic acid has been put in the ſituation to form a green precipitate with iron, by means of the oxygenated muriatic acid, ammoniac is formed as ſoon as it is mixed with alkali or lime. An acid poured into this laſt mixture no longer reſtores the odour peculiar to the pruſſic acid. Berthollet concludes that it is deſtroyed. Though he employed perfectly pure potaſh, yet an acid poured on after its action, produces an effervescence, and diſengages the carbonic acid which has been formed in every part.

Berthollet concludes, from all theſe experiments, that azot, hydrogen, and carbon, united in proportions and with a degree of condenſation which he is unacquainted with, produce that which is called the *pruſſic acid.* This compoſition explains the hiſtory of its formation in animal matters, in certain vegetable ſubſtances, and in the ammoniacal muriat, contaminated with charcoal. It likewiſe explains why this acid is ſo combuſtible, and detonates ſtrongly with the ſeveral nitrats; why it affords carbonat of ammoniac by diſtillation; and why this ſalt is formed by the addition of the oxygenated muriatic acid. Berthollet doubts whether this ſingular combination contains oxygen; at leaſt, ſays he, if the pruſſic acid contain it, the quantity is not ſufficient to reduce the charcoal entirely into carbonic acid; for the diſtillation of Pruſſian blue affords much carbonated hydrogen gas [h].

Such are the facts diſcovered by Berthollet: by determining the nature of colouring matter of Pruſſian blue, he has aſcertained that it is not a true acid, though it performs the functions of an acid in all its combinations. Weſtrumb and Haſſenfratz have diſcovered a ſmall quantity of phoſphoric acid in Pruſſian blue. The latter chemiſt has ſhown that it is not eſſential to its nature. Vauquelin and I have lately obtained pruſſic acid from the diſtillation of urinary calculus, and by treating many vegetable and animal ſubſtances with nitric acid.

Sulphat of iron decompoſes nitre very readily. This decompoſition is partly due to the ſulphuric acid, which, uniting with the alkali of nitre, diſengages the acid of that ſalt; but it is likewiſe occaſioned in a great meaſure by the re-action of the iron on the latter acid. If ſulphat of iron, ſlightly dried, be taken for this experiment, a conſiderable quantity of nitric acid, very red and fuming, is obtained; the reſidue, by lixiviation, affords ſulphat of potaſh, fixed alkali, and a red oxyd of iron remains on the filter; but if ſtrongly calcined ſulphat be made uſe of, together with nitre which has ſuffered fuſion, the product obtained is very inconſiderable. This product conſiſts of two liquors; the one of a dark, and almoſt black colour, floats on the ſurface of the other, which is red and ponderous; for which reaſon Baumé conſidered this liquor as a kind of oil; there afterwards paſſes into the neck of the retort a white ſaline maſs, which attracts the humidity of the air, and is ſoluble with heat, and great rapidity in water, emitting a ſtrong ſmell of ſpirit of nitre, and very thick red vapours: this ſolution, ſaturated with potaſh, affords ſulphat of potaſh; the white maſs therefore is merely ſulphuric acid, rendered concrete by a portion of nitrous gas.

The heavier liquor in the receiver does not, upon examination, appears to differ from Glauber's ſpirit of nitre; but the lighter liquid which floats above it, being mixed with ſulphuric acid, produces a ſtrong effervеſcence, and ſometimes a dangerous exploſion; almoſt all the nitrous acid is diſſipated, and the ſulphuric acid takes a concrete and cryſtalline form. Bucquet, who communicated this diſcovery to the Academy, had before obſerved, that the acid obtained in this diſtillation emits red nitrous vapours when diſſolved in water; he ſuppoſed that this acid owes its ſolid form to the preſence of nitrous gas, and in order to aſcertain the truth of this conjecture, he attempted to mix the brown blackiſh nitrous acid which floats above the red liquor with very concentrated ſulphuric acid; but at the very inſtant of the mixture of theſe two fluids, a commotion was excited of ſo ſtrong a kind, that the ſpirit of nitre, poured on the ſulphuric acid, was thrown with conſiderable noiſe to a great diſtance; the perſon who made the mixture was covered with the acid, and a large quantity of red and inflamed pimples immediately roſe on his face, which ſuppurated like thoſe of the ſmall-pox; the ſulphuric acid ſoon became concrete, and abſolutely ſimilar to that which is obtained in the diſtillation we have deſcribed. From this fact it appears, that the acid may become concrete as well by imbibing nitrous, as ſulphureous gas[i].

The reſidue of the diſtillation of nitre with ſulphat of iron calcined to redneſs, is merely a ſcoria of iron, from which a very ſmall quantity of ſulphat of potaſh may be obtained by waſhing.

The ſolution of ſulphat of iron is not altered by hydrogen gas, becauſe the baſe of this elaſtic fluid has leſs affinity with the oxygen than iron, as we have ſeen in the hiſtory of the decompoſition of water. Monnet has however obſerved, that ſulphurated hydrogen gas communicates to ſulphuric mother water the property of affording cryſtals; and Dr. Prieſtley has reduced the brown oxyds of iron by the contact of hydrogen gas. Theſe experiments do not contradict our doctrine, but, on the contrary, they ſerve to confirm it. In fact, the hydrogen deprives the iron of all the oxygen it was united with beyond the quantity of 0,28: this laſt doſe is merely that which the hydrogen cannot ſeparate. Hence it is that, in theſe reductions, nothing but a black oxyd, or *martial Æthiops*, is obtained, and hence water never oxydates iron, but to a black colour.

Alkaline ſulphures precipitate ſulphat of iron of a blackiſh colour; the precipitate is a kind of martial pyrites, or ſulphure of iron.

The nitric acid is very rapidly decompoſed by iron, which diſengages a large quantity of nitrous gas, eſpecially if the acid made uſe of be concentrated, and the iron in a ſtate of diviſion: this metal is quickly oxydated by the oxygen it ſeizes from the nitric acid; the ſolution is of a brown red, and depoſits oxyd of iron at the end of a certain time, eſpecially if in contact with the air. On the addition of more iron the acid diſſolves it, as Stahl has obſerved, and the oxyd of iron before held in ſolution is precipitated; nevertheleſs, when a weak nitric acid is uſed, and iron in pieces, a more permanent ſolution may be obtained, in which the metal adheres more ſtrongly to the acid. This laſt combination is greeniſh, and ſometimes of a bright yellow; both ſolutions become turbid by evaporation, and depoſit martial ochre of a reddiſh brown; but if the latter be ſtrongly concentrated, inſtead of affording cryſtals, it takes the form of a reddiſh jelly, which is only in part ſoluble in water, the greateſt part precipitating. If the nitrat of iron be kept heated, red vapours, in large quantities, are diſengaged, the magma becomes dry, and affords an oxyd of a brick-duſt red colour; this magma, by diſtillation in a retort, affords a ſmall quantity of fuming nitrous acid, much nitrous gas, and azotic gas. Vital air cannot be obtained, becauſe the iron retains all the oxygen of the acid; the oxyd which remains after the diſtillation of nitrat of iron, is of a lively red, and may afford a good colour for painters, &c. The nitric ſolution of iron, however concentrated, did not appear to afford a precipitate by the addition of diſtilled water; alkalis decompoſe it with different phenomena, according to their nature; cauſtic vegetable alkali precipitates it of a light brown colour; the mixture paſſes very quickly to a blackiſh brown, and much deeper than the colour of the firſt ſolution. This phenomenon ariſes from the portion of the precipitate diſſolved by the alkali, though the quantity be very ſmall; carbonat of potaſh ſeparates a yellowiſh oxyd, which quickly becomes of a beautiful orange red; if the mixture be agitated, an effervescence takes place, the precipitate is re-diſſolved in much greater abundance than that produced by the cauſtic potaſh. Monnet took notice of this phenomenon, and has with juſtice attributed it to the gas which is diſengaged. The ſolution of iron, by fixed alkali, is called the *martial alkaline tincture of Stahl*, and of a very beautiful red. Baumé recommends a nitric ſolution of iron, which is not highly charged, to be uſed for the preparation of this tincture: Stahl, on the contrary, adviſes a very ſaturated ſolution. Monnet has obſerved, that a yellow ſolution affords a very large quantity of precipitate, which is not reſoluble by the alkali, and does not give the colour expected in the martial tincture, while a red ſolution immediately produces it with the ſame alkali. The martial alkaline tincture of Stahl loſes its colour at the end of a certain time, and depoſits the oxyd of iron it contains; it may be decompoſed by the addition of an acid; the nitric acid ſeparates an oxyd of a brick-duſt colour, which is ſoluble in acids, and is called *Stahl's aperitive ſaffron of Mars*: pure or cauſtic ammoniac precipitates the nitric ſolution of iron of a deep, and almoſt black green; ammoniacal carbonat re-diſſolves the iron which it ſeparates from the acid, and aſſumes a more lively red colour than the tincture of Stahl. This ſolution of iron by the carbonat of ammoniac may be uſed to great advantage in caſes wherein a powerful tonic and ſolvent medicine is required.

The nitric ſolution of iron highly ſaturated, and red, afforded me but a very ſmall quantity of Pruſſian blue, by the addition of an alkali ſaturated with the colouring matter. I obtained only a blackiſh precipitate, which was re-diſſolved by the muriatic acid; the liquor had then a green colour.

Marett, ſecretary to the Academy of Dijon, has communicated to the Royal Society of Medicine a proceſs for making *martial Æthiops* very expeditiouſly ; it conſiſts in precipitating the nitric ſolution of iron by cauſtic ammoniac, and quickly waſhing and drying the precipitate. D'Arcet, who was appointed by the laſt mentioned ſociety to examine the proceſs of Marett, did not conſtantly obtain the ſame reſult. In my Memoirs on the precipitates of iron, I have determined the caſes in which the experiment of Marett ſucceeds, and thoſe in which it fails. To obtain this Æthiops it is neceſſary, 1. That the ſolution of iron be recently made in the cold, with a weak nitric acid, and iron not much divided. 2. That ammoniac be recently prepared exceedingly cauſtic, and eſpecially that it be deprived, by ſtanding, of the ſmall portion of calcareous earth, and blackiſh combuſtible matter which it uſually carries up from the ſal-ammoniac and lime, if it be not extracted in the apparatus of Woulfe. 3. That the precipitate be immediately ſeparated from the liquor, and quickly dried in cloſſed veſſels. Notwithſtanding all theſe precautions, the precipitate is not always intenſely black, but inclines towards a brown, and riſes up in the form of ſcales, whoſe inferior ſurface is blackiſh ; which ſhows that it is the contact of air which ſlightly ruſts the ſuperior ſurface. I have obtained a more beautiful *Æthiops*, and with greater certainty, by precipitating the muriatic and the acetous ſolution of iron by the fixed alkalis, and cauſtic ammoniac, and quickly drying the waſhed precipitates in cloſe veſſels ; but I think, notwithſtanding, that theſe *Æthiops*, however pure they may be ſuppoſed, always retain a ſmall part of their precipitants, and their original ſolvents, as Bayen has obſerved concerning the precipitates of mercury ; and that they cannot be employed in medicine with the ſame certainty as thoſe hertofore deſcribed. D'Arcet, in his report to the Royal Society of Medicine concerning the proceſs of Marett, has communicated a proceſs of Croharé for making *martial Æthiops*. This apothecary, who is well known by the many chemical experiments he has ſkilfully made, prepares this medicine by boiling water, acidulated by a ſmall quantity of nitric acid, on filings of iron ; the metal becomes immediately ſlightly oxydated, and affords much *martial Æthiops*, or black oxyd. But I think that the proceſs of Joſſe is preferable to every one of theſe, on account of its facility in practice, and the confidence with which its product may be uſed.

As iron is often uſed for obtaining nitrous gas, it is of conſequence to take notice, in this place, that the gas is never the ſame, but differs greatly, according to the various circumſtances of the ſolution; the nature of the acid more or leſs charged with azot and oxygen; the ſtate of the iron more or leſs greedy of oxygen; the various temperatures, &c. In general gas, prepared by this proceſs, contains a conſiderable quantity of azot; becauſe the iron is a body which abſorbs oxygen very ſtrongly, and ſeizes different quantities according to its nature and its metallic ſtate. The effects of the nitrous gas, diſengaged by means of this metal, are therefore uncertain when applied to eudiometrical reſearches. This truth, which is applicable to all bodies that ſeparate the nitrous gas from the acid of nitre, ſhows how little the trials of air by eudiometers with nitrous gas are to be depended on. Experiments of this nature made with alkaline ſulphures are much preferable.

The muriatic acid, diluted with water, diſſolves iron with rapidity, and diſengages a large quantity of hydrogen gas, produced by the decompoſition of the water, as happens when this metal is diſſolved in ſulphuric acid. It was formerly thought that the hydrogen gas produced by the action of iron on the muriatic acid was different from that which is diſengaged by the ſulphuric acid: it was thought that this elaſtic fluid was one of the principles of the muriatic acid; but the diſcovery of the decompoſition of water by iron has proved, that this acid, whoſe nature is yet unknown, is not the cauſe of the production of hydrogen gas, but that is ariſes from the water, for the acid remains entire, and without decompoſition, and requires the ſame quantity of alkali to ſaturate its ſolution as before. The ſolution of iron by the muriatic acid is attended with much heat, which continues with the ſame force till the acid is ſaturated; a proportion of the iron is precipitated in a true *Æthiops*, as happens in all other ſolutions. After filtration, this ſolution is of a green colour, inclining to yellow, and is much more permanent than the two preceding ſolutions; when preſerved in a well ſtopped phial, it does not depoſite oxyd of iron. I have kept a ſolution of this nature for eight years, which has depoſited only a very ſmall quantity of powder, of a pale yellow; but if, on the contrary, it be expoſed to the air, almoſt all the iron it contains is precipitated in a few weeks, and this precipitate is of a lighter colour in proportion as the acceſs of the air is the eaſier. It is now proved that this precipitation, which takes place equally in all the other ſolutions of iron, is produced by the oxygen of the atmoſphere, abſorbed by the metal, which becomes oxydated more and more, as I ſuſpected, in the year 1777. (See *my Memoires de Chimie*).

Stahl affirmed, that in the combination of iron with the muriatic acid, the acid aſſumed the characters of that of nitre; but this fact has not been obſerved by any other chemiſt. It ſeems that Stahl depended only on the yellow colour of this ſolution, and the ſmell it emits; a ſmell which, in fact, differs in ſome reſpects from that of ſpirit of ſalt, and approaches to that of the oxygenated muriatic acid.

The ſolution of iron by the muriatic acid does not cryſtallize regularly by evaporation. Monnet has obſerved, that if it be ſuffered to cool when it has acquired the conſiſtence of ſyrup, it forms a kind of magma, in which may be ſeen needle-form flat cryſtals, which are very deliqueſcent. This magma melts by a very gentle heat; a greater heat decompoſes it, though leſs readily than the nitrat of iron, and it aſſumes the colour of ruſt when it is dry; the muriatic acid is diſengaged from it, and may be obtained by diſtillation; it carries up with it a ſmall quantity of oxyd of iron, according to the obſervation of Brandt. The Duke D'Ayen, in one of the four excellent memoirs he communicated to the Academy, reſpecting the combinations of acids with metals, has very minutely examined what paſſes in this decompoſition of the muriat of iron. The operation afforded very ſingular products: a mild heat diſengaged a phlegm ſlightly acid; the muriatic acid then became concentrated, and its gas, which is much more volatile than water, was partly fixed by the iron: a much ſtronger heat raiſed a portion of this acid with a ſmall quantity of iron, and cryſtals were formed in the receiver, which were not deliqueſcent; very tranſparent cryſtals in the form of blades of razors, which decompoſed the light in the manner of the beſt priſms, and exhibited very beautiful tinges of red, yellow, green, and blue, were at the ſame time ſublimed to the upper part of the retort; at the bottom there remained a ſtyptic and deliqueſcent ſalt, of a brilliant colour, and foliated texture, which perfectly reſembled that kind of talc, in large plates, which is improperly called Muſcovy glaſs. This laſt ſalt, expoſed to a violent heat in a ſtone-ware retort, was decompoſed, and afforded a ſublimation ſtill more aſtoniſhing than the former products; it was an opake matter truly metallic, which, when examined by the microſcope, exhibited regular cryſtals, or ſections of hexagonal priſms, which the Duke D'Ayen compares to the pieces inlaid in floors: theſe cryſtals were as brilliant as the moſt highly poliſhed ſteel, and were ſtrongly attracted by the loadſtone. They conſiſted therefore of iron reduced in part, and ſublimed *.

Art appears here to imitate nature, which ſublimes the black oxyd of iron by volcanic fires, in the form of brilliant and well poliſhed laminæ, reſembling ſteel; ſuch at leaſt appears to be the origin of the ſpecular iron ore, and of that of Volvic, which, according to the valuable obſervations of De L'Arbre, phyſician at Riom, is always found in the clefts of lavas.

From theſe details we may perceive how rich the ſcience of chemiſtry is in curious phenomena, and what a fund of diſcovery is held forth to ſuch as perform experiments with all the accuracy of the Duke D'Ayen. We muſt not forget to obſerve, that this reduction of iron favours the doctrine of gaſes, and that we may perhaps obtain ſimilar reſults from many other metallic ſolutions treated in the ſame way.

The muriatic ſolution of iron, like all other martial ſolutions, is decompoſed by lime and alkalis; but the precipitates are leſs altered, and may be eaſily reduced, eſpecially ſuch as

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* I have in my poſſeſſion a black ore of iron, which exhibits very brilliant ſmall laminæ, of half a line in breadth, whoſe form nearly approaches to that of the cryſtals obtained by the Duke D'Ayen; they are ſmall very thin ſcales, of a very brilliant iron grey colour, placed ſlopewiſe, ſo as to interſect each other in every direction, and are diſperſed on a reddiſh opake quartz, or a kind of coarſe jaſper: this beautiful ſpecimen came from Lorrain. The iron of Framont is of the ſame nature.

are produced by the addition of cauſtic alkalis. I have before obſerved, that this combination affords the pureſt *Æthiops*, or black oxyd of iron, by precipitation. Alkaline ſulphures, ſulphurated hydrogen gas, and aſtringents, decompoſe it like the two others. Laſtly, Pruſſian alkalis, or the alkaline Pruſſiats, precipitate a beautiful blue powder.

Water charged with carbonic acid eaſily diſſolves iron: to form this combination, nothing more need be done than to add iron filings to the acid, and leave the mixture in liquid digeſtion for ſome hours; this fluid, when filtered, has a penetrating and rather ſtyptic taſte. Lane and Rouelle have taken notice of this property in the carbonic acid. Bergman, who calls this combination *aerated iron*, affirms, that when expoſed to the air, it becomes covered with a pellicle of rainbow colours; that it is decompoſed by the pure alkalis, but that theſe ſalts, when ſaturated with the acid, do not produce the ſame effect. This ſolution converts the ſyrup of violets to green, and affords very brilliant Pruſſian blue with the calcareous Pruſſiats; it precipitates the brown oxyd of iron when left expoſed to the air, or when heated: this combination we have named *carbonat of iron*. Iron has a ſtrong tendency to unite with the carbonic acid, and nature very frequently preſents it in this ſtate. The muddy iron ores and ſpathoſe iron appear to be in a great meaſure formed by this combination; ferruginous mineral waters often contain iron in the ſtate of carbonat of iron. This ſalt, ſeparated from the water and dried, is ſcarcely ſoluble in that fluid, but it diſſolves in a large proportion in the liquid carbonic acid, from which it is precipitated in proportion as the acid is volatilized. The action of the boracic and fluoric acids on iron is not known[k].

This metal decompoſes ſulphuric ſalts very readily, and in particular the ſulphats of potaſh and of ſoda. I have treated theſe ſalts with iron in a crucible, and have found them to be in the ſtate of ſulphures. The lixivium of this kind of ſulphure is of a very deep green; a few drops of acid cauſed the colour to diſappear very quickly. The greateſt part of the iron oxydated by the oxygen of the ſulphuric acid, remains without diſſolving in the lixivium, and acids diſengage from this oxyd a large quantity of ſulphurated hydrogen gas.

Iron cauſes nitre to detonate. When equal parts of ſteel filings, and very dry nitre, are thrown into a well ignited crucible, a very rapid commotion is excited after a little time, and a great number of brilliant ſparkles fly out of the crucible. When the detonation is ended, the crucible contains a reddiſh oxyd of iron, of which a ſmall portion is combined with the alkali; water diſſolves the alkali, and the oxyd of iron remains on the filter. This oxyd was formerly called *Zwelfer's ſaffron of Mars*, and is of a yellowiſh red, ſcarcely ſoluble in acids; the alkali ſeparated by the lixiviation is cauſtic, according to moſt chemiſts, who think that metallic oxyds act like pure lime on this ſalt, charged with the carbonic acid *.

Iron decompoſes ammoniacal muriat very readily: two drachms of ſteel filings triturated with one drachm of this ſalt, diſengage ammoniacal gas. Bucquet, who diſtilled this mixture in the pneumato-chemical apparatus with mercury, obtained fifty-four cubic inches of an aeriform fluid, half of which was ammoniacal gas, and the other half hydrogen gas. Four ounces of the ſame filings, and two ounces of ammoniacal muriat, diſtilled in the retort with the common receiver, afforded about two drachms of liquid ammoniac, containing a ſmall quantity of iron, which was ſoon after depoſited in the form of an oxyd; the reſidue of theſe operations was muriat of iron. The decompoſition of ammoniacal muriat by iron, is a conſequence of the facility with which this metal unites with the muriatic acid, which is proved by the diſengagement of hydrogen gas obſerved in this experiment. A ſalt is prepared for medical uſes, with ammoniacal muriat and iron, which is called *martial flowers of ſal-ammoniac*, or *ens martis*. One pound of ammoniacal muriat in powder, and one ounce of iron filings are mixed together. The mixture is expoſed in an earthen veſſel, covered with a veſſel of the ſame kind, to a heat capable of igniting the lower part of the apparatus: in five or ſix hours a yellow matter is ſublimed, which is preſerved in a bottle: this is the *martial flowers*, and conſiſts moſtly of ammoniacal muriat ſublimed, with a ſmall quantity of oxyd of iron. As this metal decompoſes muriat of ammoniac very readily, it muſt only be employed in ſmall quantities, in order that the greateſt part of the ſalt may ſublime in its proper ſtate. The portion of oxyd of iron which is volatilized colours the ammoniacal muriat ſublimed at the ſame time.

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* It muſt be obſerved, that ſince the promulgation of the theory of Dr. Black, reſpecting the cauſticity of lime and alkalis, the neceſſary experiments have not been made to aſcertain this parity of action between lime and metallic oxyds; nothing can therefore be ſaid reſpecting this, till ſuch experiments have been made. *Note of the Author.*

Oxyd of iron decompoſes this ſalt more readily than the metal itſelf, ſince it diſengages the ammoniac in the cold. That which is obtained by diſtillation is very fluid and cauſtic. I have obtained ammoniac, which made a ſlight effervefcence with acids, by diſtilling ammoniacal muriat with half its weight of *aperitive ſaffron of Mars*, or oxyd of iron formed by the contact of air; in this experiment, the carbonic acid diſengaged from the iron, unites with the ammoniac, and renders it effervefcent.

Iron is altered in its colour by hydrogen gas, but this change has not yet been ſufficiently examined. The black oxyd of iron is not decompoſed by this gas; but the brown or red oxyds are eaſily changed, and paſs to the ſtate of black oxyd, becauſe they yield to the hydrogen the quantity of oxygen which is ſuperabundant to that which places the iron in the ſtate of black oxyd.

Sulphur combines rapidly with iron: a mixture of iron filings and ſulphur in powder, moiſtened with a ſmall quantity of water, becomes hot in a few hours, at which time it ſwells up, its parts adhere together, it abſorbs the water, breaks with a perceptible noiſe or crackling, and emits aqueous vapours, attended with a very manifeſt odour, reſembling that of ſulphurated hydrogen gas. If the mixture be made in a large quantity, it takes fire in twenty-four or thirty hours, as ſoon as the aqueous vapours have ceaſed. Towards the end of the action of theſe ſubſtances on each other, the heat becomes greater and greater, and is quickly ſucceeded by inflammation; the ſmell is then much ſtronger, and appears to ariſe from the hydrogen gas produced by the re-action of the ſulphur and the iron on the water. This ſmell is a mixture of that of alkaline ſulphures and of pure hydrogen gas, and it is doubtleſs owing to the large quantity of this gas which is diſengaged, that the inflammation is due; for the flame is much more lively than that of ſulphur, and it riſes to a foot in height according to the report of Baumé, who obſerved that this phenomenon with a mixture of an hundred pounds of filings of iron, and as much ſulphur in powder, did not laſt longer than two or three minutes; but the mixture remained red hot for forty hours. Baumé explains this inflammation by the diſengagement of the phlogiſton of the ſulphur, in the form of fire ſet at liberty. Lemery the elder gave the name of artificial volcano to this experiment, and imagined that the fires which burn in the interior part of our globe, and by raiſing the ſurface produce earthquakes and volcanoes, were owing to a ſimilar combuſtion of pyrites in large maſſes moiſtened. Theſe terrible effects may be imitated, according to the ſame chemiſt, by burying in the earth a mixture of ſulphur in powder, and filings of iron, reduced into a paſte with water, and covering it up with earth ſtrongly rammed down. The experiment, however, did not ſucceed with Bucquet, who repeated it with great exactneſs; and the reaſon may be eaſily deduced, from the experiments of Prieſtley. This philoſopher obſerved, that a mixture of iron and ſulphur, when moiſtened, abſorbed a certain quantity of air, which appears to be neceſſary for this inflammation. Nevertheleſs, this inflammation may take place without the contact of air. In fact, it appears that the iron, which is greatly divided, reacts on the water, ſeizes its oxygen, by which it burns, and ſuffers the hydrogen gas to be diſengaged, which takes the elaſtic form, by reaſon of the heat ſeparated from the water: the gas likewiſe diſſolves a portion of the ſulphur, and forms ſulphurated hydrogen gas.

There is a great analogy between this combination of iron and ſulphur, by the humid way, and the efflореſcence of *pyrites*, which afford ſulphurated hydrogen gas, when they are moiſtened with water.

Sulphur combines very readily with iron by fuſion, and produces a ſulphure of iron, or *pyrites* diſpoſed in needles. As the fulphur in this caſe greatly increaſes the fuſibility of iron, that metal may be inſtantly fuſed by the aſſiſtance of the combuſtible body. For this purpoſe, a ſmall bar of iron, heated to whiteneſs, may be applied to a roll of ſulphur, and the melted matter which drops may be received in a veſſel of water; it is found to conſiſt of blackiſh brittle globules, ſimilar to *pyrites*, and, like them, formed of ſmall ſlender pyramids, converging to a centre [l].

Iron combined with arſenic, affords a brittle alloy, very little known. It appears that this metal exiſts in many ores of iron, and is the cauſe of the *hot ſhot* iron.

With cobalt it conſtitutes a mixed metal, cloſe-grained, hard, and difficult to break.

It does not appear capable of uniting with biſmuth.

Combined with antimony, it forms a hard alloy, with ſmall facets, which ſcarcely yields to the hammer. Iron has a ſtronger affinity with ſulphur than with this brittle metal, and conſequently is capable of decompoſing ſulphure of antimony. To effect this, five ounces of the points of horſe ſhoe nails are heated red hot in a crucible; a pound of pulverized ſulphure of antimony is then thrown in, and a ſtrong heat ſuddenly given to melt the mixture; when it is well fuſed, an ounce of nitre in powder is added, to aſſiſt the fuſion, and facilitate the ſeparation of the ſcoriæ from the antimony. The mixture being ſuffered to cool, antimony is found in the crucible, which does not contain iron; but if one part of iron be uſed with two of ſulphure of antimony, the antimony will be alloyed with iron. The ſcoriæ, which are found above the antimony alloyed with iron, and prepared with nitre and tartar, have a yellowiſh colour, ſimilar to that of amber, produced by the iron they contain, whence Stahl called them *ſuccinated ſcoriæ*. He directs them to be reduced into powder, and boiled in water, which takes up the moſt ſubtle part of the powder; after which the fluid muſt be decanted off, filtered, and the powder on the filter detonated three times with nitre: this being waſhed and dried, is *Stahl's aperitive* and *antimoniated ſaffron of Mars*.

It is ſtill uncertain whether zink be capable of uniting with iron. Malouin, in his Memoir on Zink, publiſhed among thoſe of the Academy for the year 1742, has ſhown, that this metal may be applied, like tin, to the ſurface of iron, for the purpoſe of defending it from the contact of air, a circumſtance which ſhows that theſe two metallic matters are capable of combining.

It ſeems that nickel is capable of being very intimately united with iron, ſince theſe two metallic ſubſtances can never be perfectly ſeparated, as Bergman has demonſtrated.

Mercury does not contract any union with iron in its metallic ſtate; it has in vain been attempted to unite theſe two metals immediately, but the combination is ſuccefsfully made by preſenting them to each other in the ſtate of oxyds. Navier has obſerved, that a whitiſh ſnowy precipitate is obtained, by mixing a ſolution of iron and of mercury by the ſulphuric acid, and evaporating the mixture; in this operation ſmall flat cryſtals, ſimilar to thoſe of boracic acid, are formed. Navier affirms, that theſe cryſtals are a combination of iron and of mercury.

Lead is not capable of uniting with iron.

Iron and tin appear ſuſceptible of union by fuſion. The preparation of *white iron*, or, as it is commonly called, tin, which conſiſts of iron plates covered with a thin ſtratum of tin, ſhows that this combination takes place. In order to tin iron, it is neceſſary that the ſurface of the metal ſhould be very clear and bright; for that purpoſe it is corroded by an acid, or ſometimes filed or ſcraped, or covered with a ſolution of ſal-ammoniac; it is afterwards plunged vertically into a veſſel of melted tin, moved backwards and forwards, to increaſe the contact, and when ſufficiently tinned, it is taken out and rubbed with ſaw-duſt, or bran, to clear off the fat or pitch with which the melted tin was covered, and which adheres to the ſurface of the tinned iron. If iron reduced into very thin laminæ be tinned, the tin will not only apply to the ſurface, but will penetrate into its internal parts, and the combination will be perfect throughout; ſo that when it is cut, the ſame white colour will be obſerved in the middle as at its ſurface, a circumſtance which ſhows, that well made tin-plate is a true chemical combination; it is beſides more malleable than iron, and is wrought into veſſels of ſuch forms, as it would be impoſſible to give to pure iron by the hammer.

We have ſeen, at the commencement of this chapter, that iron readily abſorbs charcoal by heat, and that it forms *caſt iron* and *ſteel* by its union with this combuſtible ſubſtance; with this difference, however, that it contains oxygen in the former of theſe compounds, but not in the latter. In both, the quantity of iron greatly exceeds that of the charcoal. Chemical analyſis, which is ſo much indebted to the labours of Scheele, has proved to this chemiſt, that *plumbago*, a mineral whoſe nature and rank among other minerals had long embarraſſed philoſophers, is nothing more than a natural combination of a large proportion of charcoal with a very ſmall quantity of iron; its hiſtory muſt, therefore, belong to that of this metal [m].

Plumbago was a long time confounded with *molybdena*. It is known that the ſubſtance, which is now called molybdena, is the oxyd of a peculiarly acidifiable and brittle metal, of which we have already given an account. Pott is the firſt who proved that neither of theſe ſubſtances contains lead, as was anciently thought.

The many names by which *plumbago* and *molybdena* have been diſtinguiſhed, ſerve to increaſe, or at leaſt to perpetuate, theſe errors. Both, without diſtinction, were called *lead ore*, *Engliſh crayon*, *plomb de mer*, *black ceruſe*, *mica of the painters*, *crayon of lead*, *falſe galena*, *talc*, *blende*, *potelot*.

The native carbure of iron (a name which has been ſubſtituted for that of plumbago, and which is expreſſive of the nature of the compound), is found in mountains, often between beds of quartz, felt ſpar, clay, or calcareous earth, in the form of roundiſh irregular pieces, of different magnitudes; the largeſt of which weigh from eight, to ten or eleven pounds: it is likewiſe found diſſeminated in much ſmaller fragments, and ſometimes even in beds or ſtrata. The inhabitants of Bleoux, a village near Curvan, in Upper Provence, find native carbure of iron, or plumbago in ſtrata, four feet thick, between two ſtrata of clay. This is ſold at Marſeilles. La Peyrouſe reckons carbure of iron among the minerals of the Pyrenean mountains. It is likewiſe found in Spain and Germany, and alſo in the county of Cumberland in England, where it is made into pencils, which are highly eſteemed. North America, and the Cape of Good Hope, likewiſe afford ſome ſpecimens. Within theſe few years, *plumbago*, cryſtallized in octahedrons, has been diſcovered.

Carbure of iron is of a ſhining blue black, of a greaſy feel, and tuberculated fracture; whereas the fracture of *molybdena* is lamellated. Its unctuous and ſaponaceous quality, cauſed ſome naturaliſts to conſider it as a ſpecies of impure clay. It ſoils the hands, and makes a black trace on paper, which is very well known to every one.

Carbure of iron is not altered by fire in cloſe veſſels. Pelletier, who has made experimental inquiries on this ſubſtance, which confirm the reſults of Scheele, expoſed 200 grains in a porcelain crucible, accurately cloſed, to the heat of the furnace of the manufactory of Seve. The loſs was no more than 10 grains. But when it is heated with contact of air, it burns, and is oxydated, without leaving ſcarcely any reſidue. Quiſt, Gahn, and Hielm, obſerved, that 100 grains, treated in this manner, in a muffle, left only 10 grains of ferruginous oxyd. This oxydation is a ſlow combuſtion, not eaſily performed. It does not ſucceed in a common crucible: a thin layer of carbure of iron muſt be expoſed, in a ſhallow veſſel, to the action of a ſtrong fire, and the ſurfaces muſt be often renewed, by ſtirring the matter. It is in this way that the carbure of iron employed to cover ſtones, &c. is gradually burned.

Air, water, and earthy ſubſtances, have no action on carbure of iron.

Alkalis act ſtrongly on this ſubſtance. If one part of carbure of iron, with two parts of dry cauſtic fixed alkali, or *lapis cauſticus*, be expoſed to heat in a retort, with the pneumato-chemical apparatus, the ſmall quantity of water contained in the ſalt is ſufficient to favour the combuſtion: carbonated hydrogen gas is obtained, the alkali is charged with carbonic acid, and the carbure of iron is found to have diſappeared. This experiment, as well as the detonation with nitre, hereafter to be mentioned, cauſed Scheele to conclude, that this matter is a kind of ſulphure, compoſed of the *aerated*, or carbonic acid and phlogiſton. This theory ſhall be diſcuſſed, after we have examined the other phenomena, exhibited by this combuſtible body with acids and neutral ſalts.

The ſulphuric acid has no action on carbure of iron according to Scheele. Pelletier has obſerved, that 100 grains of this ſubſtance, and four ounces of concentrated ſulphuric acid, being digeſted for ſeveral months in the cold, the acid acquired a green colour, and the property of congealing, by a very ſlight degree of cold. This acid, diſtilled from carbure of iron, paſſes to the ſulphureous ſtate, by burning part of that ſubſtance.

The nitric acid has no effect whatſoever on carbure of iron. The muriatic diſſolves the alumine and the iron, and ſerves to purify it, according to Berthollet. Pelletier uſed the ſame proceſs, in order to obtain carbure of iron in a ſtate of purity. As to the alumine which the muriatic acid takes from carbure of iron, Scheele obſerves, that that which he obtained in his analyſis, came from the crucible in which he had before treated that ſubſtance.

Carbure of iron, fuſed with four parts of ſulphat of potaſh, or of ſoda, produces alkaline ſulphures, and is entirely decompoſed.

Nitre detonates by the addition of this mineral, ten parts of the ſalt being neceſſary for the complete combuſtion of one part of carbure of iron. The fixed alkali, which remains after this operation, effervеſces ſtrongly with acids, and contains a ſmall quantity of oxyd of iron. The ſame effect follows, when nitrat of ſoda, or of ammoniac, is uſed. Pelletier has obſerved, that in this laſt operation the ammoniac is diſengaged, in combination with a portion of the carbonic acid.

Carbure of iron does not act on the muriat of potaſh, nor on the muriat of ſoda.

When diſtilled with ammoniacal muriat, it affords *martial ammoniacal flowers;* heated with ſulphur in a retort, the ſulphur ſublimes alone, without affecting the carbure of iron in the leaſt.

All theſe facts prove that this ſubſtance is not an earth or ore of lead, as had been imagined; but the theory of Scheele, who conſiders it as a combination of the carbonic acid and phlogiſton, cannot be admitted; 1. Becauſe that chemiſt did not aſcertain the quantity of acid produced. 2. Becauſe he has not artificially produced *plumbago*, by combining the carbonic acid with a combuſtible ſubſtance. Moreover, the two ſubſtances, by the addition of which Scheele changed carbure of iron into carbonic acid, appear to effect this converſion, by affording vital air, which, combining with the inflammable matter of that ſubſtance, produces the carbonic acid by the fixation of the oxygen; for ſuch is the proceſs by which the nitric acid converts tungſten, arſenic, and ſugar, into acids. The cauſtic fixed alkali likewiſe converts carbure of iron into carbonic acid, evidently in conſequence of the water that alkali always contains, and which burns the combuſtible matter, as it does iron and zink. This opinion is confirmed by the hydrogen gas obtained during the reciprocal action of the alkali and the carbure of iron; and it might be ſtill more confirmed by paſſing the vapour of water over this ſubſtance, made red hot in a tube of copper, in the ſame manner as the experiment is made with iron and zink. And though this has not yet been tried, I think I may venture to predict, that all the carbure of iron would be deſtroyed, and converted into carbonic acid; and that the product of this operation would conſiſt of carbonated hydrogen gas, mixed with a large quantity of carbonic acid. It would therefore ſeem natural to conclude, that the carbonic acid is a compound of plumbago and of oxygen. But as we know, by many other experiments, that this acid is very abundantly produced by combining charcoal with oxygen, it follows, that *plumbago* contains a large quantity of carbon, and that it is almoſt wholly compoſed of this combuſtible ſubſtance: a few leading circumſtances reſpecting the properties of carbon compared with thoſe of carbure of iron, will ſhow this more evidently.

The charcoal of many vegetable matters is brilliant, and of a metallic aſpect, like carbure of iron; ſoils the hands, and leaves traces on paper; is brittle, and of a granulated fracture. The moſt brilliant charcoals, ſuch as thoſe of certain animal ſubſtances, are as difficult to burn as carbure of iron, which requires to be frequently ſtirred, at the ſame time that it is expoſed to a ſtrong heat, with contact of air, conſtantly renewed; both contain iron; and, laſtly, both are ſuſceptible of being changed into carbonic acid by combuſtion. May we not from hence conſider *plumbago* as charcoal formed in the interior part of the globe, or buried in the earth? May we not even ſuppoſe that this matter is formed by the combination of certain mineral principles, though almoſt all chemiſts have concluded that organic bodies only are convertible into charcoal? Theſe ideas may be confirmed or deſtroyed by a connected inquiry into the ſtate of carbure of iron in nature, the circumſtances of its formation, the changes to which it is ſubjected. Since the knowledge acquired reſpecting carbure of iron by the reſearches of Vandermonde, Monge, and Berthollet, into the different ſtates of this metal, they have diſcovered that a ſubſtauce is daily formed in the fuſion of caſt iron, which is entirely ſimilar to the native carbure of iron. It is rare that the ladles with which the crude iron is taken out are not covered with it. The ruins of the ſmelting furnaces which are repaired exhibit it likewiſe in conſiderable maſſes, in a cryſtallized form. It is to be hoped that at ſome future period it may be artificially prepared for the uſes of ſociety[n].

Carbure of iron is of conſiderable uſe. Pencils are made of it; the beſt come from England. The Engliſh black lead comes from Keſwick, in the county of Cumberland. It is cut into thin plates, the edge of which being fitted into a groove, in a ſemi-cylinder of wood, it is then ſawed off, ſo as to leave the cavity entirely filled. The mineral is retained in its place by the other half of the cylinder, which is glued on. The powder produced in this operation ſerves to make pencils of an inferior quality; great numbers of which are ſold in Paris. It is either mixed with gum water, or fuſed with ſulphur. Theſe inferior pencils are known, either by their taking fire at the flame of a candle, or their falling into powder by moiſtening in water. German carbure of iron is likewiſe uſed to make pencils, with the addition of various foreign ſubſtances, ſuch as charcoal, ſulphur, &c.

The very fine powder of carbure of iron is uſed in England inſtead of greaſe, to facilitate the motion of the axes of certain mechanical inſtruments, which it effects by its unctuous quality.

One of the principal uſes of this ſubſtance is to cover iron which is to be defended from ruſt. The pipes of ſtoves, chimney-plates, and other utenſils, expoſed to the action of fire and air, are covered with carbure of iron in powder, applied to their ſurface by ſimple friction with a bruſh. Homberg, in the year 1699, deſcribed a proceſs for giving a leaden colour to iron utenſils. It conſiſts in mixing eight pounds of lard, melted with four ounces of camphire, together with a ſufficient quantity of carbure of iron: the iron is to be ſmeared with this compoſition when it is almoſt too hot to retain it, and muſt be rubbed with a cloth when cold.

The makers of ſmall ſhot poliſh and blacken its ſurface, by agitating or rolling it in a caſk with powder of carbure of iron. This mineral likewiſe enters into the compoſition for razor ſtraps. Laſtly, It is an ingredient in certain black pottery in England, and in crucibles made at Paſſaw in Saxony. Pelletier, who has well deſcribed the ſeveral uſes of carbure of iron, prepares a lute or coating, after Pott, conſiſting of one part of this ſubſtance, three of common clay, and a ſmall quantity of cow dung, chopped very ſmall. This coating ſupports glaſs retorts ſo well, that they ſometimes may be even melted without producing any change in its form.

The uſes of iron are ſo great and extenſive, and beſides ſo well known, that it would be uſeleſs to attempt to enumerate them: it is only neceſſary to obſerve, that no art can be carried on without it, and that it is the ſoul of all the arts, as Macquer obſerves. The different modifications it is ſuſceptible of, render it very proper for the multiplicity of purpoſes to which it is applied. Caſt iron ſerves to form utenſils of various degrees of ſolidity as may be required. The hardneſs and tenacity of the ſeveral kinds of forged iron are no leſs applicable to other uſes. The ſame obſervation is applicable to ſteel: the fineneſs of the grain, and excellence of the temper, conſtitute a great number of ſpecies, peculiarly adapted to an almoſt infinite number of arts. The oxyds of iron ſerve to give a red or brown colour to porcelain, enamel, pottery, &c. they are likewiſe uſed in the preparation of artificial precious ſtones, and combined with oil for painters. Iron is the baſis of an important medicine, which is frequently applied with the greateſt ſucceſs. It is the only metal which is not noxious, and whoſe effects are not to be feared; it has, even as we have ſeen, ſuch an analogy with organic matters, that it ſeems to form part of them, and often owes its production to the proceſſes of life or vegetation. The effects of iron on the animal economy are numerous; it ſtimulates the membranes of the viſcera, and appears to act more eſpecially on thoſe of the muſcles, which it braces; it fortifies the nerves, and gives a remarkable degree of force and vigour to the animal ſyſtem; it excites many ſecretions, eſpecially the urinary and menſtrual evacuations; it increaſes the contractions of the heart, and conſequently renders the pulſe ſtronger and quicker. Its action is not leſs effectual on the fluids; it paſſes quickly through the firſt paſſages, and combines with the blood, to which it gives denſity, conſiſtence, and colour, rendering it more concreſcible, communicating at the ſame time ſuch a degree of activity as enables it to paſs eaſily into the ſmalleſt veſſels, which it ſtimulates at the ſame time, and communicates force and life through every part. The capital experiments of Menghini, publiſhed in the Memoirs of the Inſtitution of Boulogne, have proved, that the blood of perſons, who take *martial medicines*, is highly coloured, and contains a larger quantity of iron than it would naturally contain. Lorry, who exerciſes the art of medicine with that accuracy of obſervation which characterizes the true philoſopher and phyſician, obſerved, the urine of a patient to whom he had given iron, in a very divided ſtate, became manifeſtly coloured with nutgall. This metal is therefore tonic, fortifying, ſtomachic, diuretic, alterative, inciſive, and unites in its action the properties of a great number of other medicines. Like aſtringents, it increaſes the motion of the parts, and has the advantage of being more conſtant and durable in its effects than many other remedies which poſſeſs the ſame virtue, becauſe it combines with the organs themſelves, by means of the fluids which ſerve for their nutrition. It ſeems, therefore, that in every caſe wherein the fibres of the viſcera, of the muſcles, or even of the nerves, have only a very feeble action, in languors of the ſtomach, and ſluggiſhneſs of the inteſtines, and in weakneſſes produced by theſe cauſes; in fine, in all the caſes wherein the fluids are not ſufficiently conſiſtent, or too much diluted, as in palſies and propenſities to the dropſy, &c. iron may be adminiſtred with ſucceſs. It is uſed under many different forms, ſuch as the levigated filings, martial Æthiops, aſtringent and aperitive ſaffron of Mars, martial alkaline tincture of Stahl, the martial flowers of ſal-ammoniac, &c. to theſe we may perhaps add, iron precipitated by an acid, and re-diſſolved by pruſſiat of iron; the Pruſſian blue propoſed by the chemiſts of the Academy of Dijon, &c. The ſulphat of iron is externally uſed in hemorrhages, &c.

Iron which poſſeſſes the magnetic property, or the artificial magnet, has been reckoned among thoſe bodies which produce very ſingular effects upon the animal economy. When applied to the ſkin, according to ſeveral modern authors, it mitigates pain, diminiſhes convulſions, excites redneſs, ſweat, and often a ſmall eruption: it is likewiſe capable of rendering epileptic attacks leſs frequent. It has even been affirmed, that, when left in water for twelve hours, it communicates a purgative property to that fluid. All theſe aſſertions, which are ſaid to be founded on facts, ſufficiently announce to enlightened philoſophers the great difficulty which attends phyſical reſearches into the animal ſyſtem. The abſolute inefficacy of a body, rendered magnetical, or armed with the magnetical power, upon other bodies which are not ſuſceptible of receiving the ſame power, truly excludes the influence of magnetiſm upon the animal economy: thoſe phyſicians who attribute ſuch evident and ſtriking effects, and conſequently ſuch energetic medicinal properties to the magnet, have been ſeduced and deceived by changes more or leſs ſenſible, which have taken place at the time of the application of the magnet, and were owing to the proper forces of the individuals, and the happy efforts of nature. This opinion is ſo much the better founded, as it is more eſpecially in the ceſſation or tranſpoſition of local pains or convulſions that nature exhibits the greateſt inconſtancy and irregularity to obſervers; and that it is particularly from ſymptoms, more or leſs analagous to theſe, that the pretended medicinal properties of the loadſtone have been inferred.

NOTES ON CHAPTER XVIII.

IRON.

a The exiſtence of phoſphorus in ſome ſpecies of ſteel is fully aſcertained by the following experiment of Vauquelin. 576 grains of ſteel filings were diſſolved in ſulphuric acid, diluted with five parts of water. From this ſolution, ſaturated with carbonat of potaſh, 19 grains of a white taſteleſs powder were depoſited, completely ſoluble in muriatic acid. This matter, by boiling it in a ſolution of cauſtic ſoda, aſſumed a deep red colour, and was greatly diminiſhed in its volume. The liquor being filtered, and mixed with concentrated muriatic acid, gave no ſign of effervеſcence; and formed, before and after its mixture with muriatic acid, a white precipitate, by the addition of lime water. On examination this precipitate was found to be phoſphat of lime.

b Clouet ſays a 1-32d part of charcoal is ſufficient to convert iron into ſteel. In a quantity equal to one 1-6th of the iron it affords a ſteel more fuſible and ſtill malleable, but beyond this term it approaches to caſt iron, and has not a ſufficient degree of tenacity. *Ann. de Chem.* Tom. XXVIII. *Journ. de Phyſ.* Tom. LIII. p. 373. *Mem. de l'Acad.* 1786, p. 204.

c A new method of preparing caſt ſteel has been lately announced in France by Clouet. His proceſs is the following: Take ſmall pieces of iron and place them in a crucible, with a mixture of carbonat of lime and the earth of Heſſian crucibles; 6 parts of the carbonat of lime, and 6 of this earth, muſt be employed for 20 parts of iron. The mixture is to be diſpoſed ſo, that after fuſion the iron may be completely covered by it to prevent the iron from coming into contact with the external air. The mixture is then to be gradually heated, and at laſt expoſed to a heat capable of melting iron. If the fire be well kept up, an hour will generally be ſufficient to convert two pounds of iron into excellent and exceedingly hard ſteel, capable of being forged; an advantage not poſſeſſed by ſteel in the common manner. *Phil. Mag.* Vol. II. p. 219.

The oxyds of iron are equally ſuſceptible of paſſing to the ſtate of ſoft iron, ſteel, and caſt iron, according to the quantity of carbon employed. The black oxyd, the ſtate of which ſeems to be the moſt unalterable, becomes iron when treated in the crucible with an equal volume of charcoal duſt. By doubling the quantity of the charcoal, ſteel is formed, and a progreſſive increaſe gives it the characters of white and grey caſt iron. A fifth part only of caſt iron is required to convert iron into ſteel. The iron and the oxyd do not unite intimately. The black oxyd, mixed with one half leſs of carbon than is neceſſary for its reduction, gives a ſoft iron, but not very tenacious, black, and without a granulated fracture. A ſixth part of the oxyd brings back common ſteel to the ſtate of iron, by treating them together, either in the forge or by cementation. *Annal. de Chem.* Tom. XXVIII.

d The ſolubility of iron in water, either in the ſtate of a metal or an oxyd, has been more than ſufficiently diſproved by the numerous and accurate experiments of Weſtrumb. *Kleine Abhandlungen*, B. III. ſ. 249.

[e] When ſteel, or iron containing carbon, are diſſolved in ſulphuric acid, the hydrogen gas evolved will diſſolve and hold in ſolution a greater or leſs quantity of carbon, according to the concentration of the acid, and the degree of temperature in which the ſolution is made. When the iron or ſteel diſſolved contains phoſphorus, a portion of this ſubſtance will alſo be diſſolved by the hydrogen gas. Its preſence is eaſily recogniſed by the extremely offenſive ſmell which it exhales. From the ſolution of 100 grains of four different kinds of ſteel, diſſolved in ſulphuric acid, Vauquelin obtained hydrogen gas in the following proportions:

	Cubic inches.
Firſt kind, - -	108
Second kind, - -	121
Third kind, - -	114
Fourth kind, - -	108

[f] Prouſt affirms, that theſe two ſulphats differ from each other in the quantity of oxygen which they contain. Lavoſier had ſhown that iron in the green or cryſtallizable ſulphat contains $\frac{27}{100}$ oxygen. According to Prouſt the red ſulphat contains not leſs than $\frac{48}{100}$ of the ſame principle. The properties of the compounds formed by the union of acids with iron, will differ according as the metal is oxydated to its maximum of $\frac{48}{100}$, or its minimum of $\frac{27}{100}$. Prouſt affirms that there is no intermedium between theſe two ſtates. *Ann. de Chem.* Tom. XXIII. p. 86.

[g] Prouſt alſo, in a memoir on the ſame ſubject, deſcribes two kinds of pruſſiat of iron. The firſt he terms the *white pruſſiat.* It is prepared by mixing a ſaturated ſolution of potaſh with a ſolution of pure green ſulphat of iron. The external air is to be carefully excluded from the veſſel in which the mixture is made. A copious white precipitate is immediately formed, which gradually acquires a green tinge from the air contained in the veſſel. The action of oxygen is evinced by the blue colour it acquires from expoſure on the filter to the action of the air. The colour of the pruſſiat arrives at its greateſt degree of intenſity only when the iron becomes oxydated to its maximum of $\frac{48}{100}$. Of all the ſaline combinations of iron, the baſe of this pruſſiat has the ſtrongeſt tendency to ſaturate itſelf with oxygen. Sulphuric and muriatic acids produce no change on the white pruſſiat of iron. The oxygenated muriatic acid gives it inſtantly a blue colour, during which the acid loſes its peculiar ſmell. The ſame colour is produced, but more ſlowly, by the addition of nitric acid. A ſolution of ſulphurated hydrogen has no action on the white pruſſiat, but it reſtores the white colour to pruſſiat which has already become blue, by depriving it of the oxygen, which, from expoſure to the air, it had abſorbed.

The ſecond is the *blue pruſſiat of iron.* This combination is formed directly by adding the pruſſiat of potaſh to the red ſulphat of iron, to the nitrat, and to all the acid ſolutions in which the oxyd of iron is at its higheſt degree of oxydation. The colour is perfect as ſoon as the pruſſiat of iron is formed, ſo that expoſure to the atmoſphere can add nothing to it. The knowledge of this fact enables us to underſtand why the red ſulphat and the nitrat of iron decompoſe ſulphurated hydrogen. The converſion of the blue into the white pruſſiat may be alſo effected by keeping it ſhut up in a well corked flaſk, with water and plates of iron or tin. The plates of metal take from the oxyd of the pruſſiat the oxygen which it has in exceſs, in the ſame manner as mercury decompoſes the oxygenated muriat of that ſubſtance.

h The conjecture of this moſt experienced and enlightened chemiſt has been converted into an eſtabliſhed truth by the following happy experiment of Clouet. Two parts and a half of quicklime were mixed with one part of dry pulverized muriat of ammoniac, and introduced into a ſtone retort. The retort was placed in a ſand bath, and a porcelain tube, filled with dry powdered charcoal, adapted to it. The other extremity of the tube was connected with a ſeries of tubulated jars, containing ſubſtances fitted to abſorb the different gaſes which might come over during the courſe of the experiment. The firſt jar contained a ſaturated ſolution of ſulphat of iron, the ſecond the ſame ſolution diluted in water with an exceſs of acid, and the third a nitric ſolution of iron with an exceſs of acid. The porcelain tube was ſurrounded with fuel, and made red hot, and the fire then applied to the retort. Ammoniac was immediately diſengaged; but no ſooner had the vapours paſſed over into the firſt jar than a large quantity of Pruſſian blue was precipitated. There was none formed in the ſecond jar nor in the third; from which, however, a ſtrong ſmell of nitrous gas was exhaled. Alkali was added in exceſs to the ſecond and third jars, and in a ſhort time the Pruſſian blue began to appear in them alſo.

Clouet varied this experiment by filling the firſt jar with diluted ſulphuric acid in order to abſorb any uncombined ammoniac that might paſs over, the ſecond with diſtilled water, the third with cauſtic mineral alkali, and a fourth with filings of iron and diluted ſulphuric acid.

When an end was put to this experiment, the firſt jar was found to contain not only ſulphat of ammoniac, but alſo a certain quantity of the colouring matter; the ſecond contained the colouring matter in a very pure ſtate, but it produced the blue precipitate only in thoſe acid ſolutions of iron to which ſome alkali had been previouſly added. In the third jar the mineral alkali was found combined with a large quantity of this colouring matter; and in the fourth jar, containing the ſulphuric ſolution of iron, a very ſmall quantity of Pruſſian blue had been formed. The precipitate from theſe ſolutions was of a blue colour, with a ſlight tinge of green. It acquired, however, a beautiful blue colour by the addition of a little nitric acid, or aqua regia, to the liquor in which it was formed.

After ſtanding for ſome time, theſe liquors depoſited a conſiderable quantity of a browniſh matter. This matter, which was very bulky and light when ſeparated from the liquor, filtered and dried, was found, on examination, to be charcoal that had not been completely diſſolved by the ammoniac.

Clouet tried to combine the principles of ammoniac, in different proportions, with charcoal, in order to produce this colouring matter, but without ſucceſs.

During the courſe of the experiment, ſeveral other gaſes were diſengaged which did not contain any colouring matter. Theſe gaſes were for the greater part azotic gas, a little carbonic acid gas, and ſometimes a ſmall portion of hydrogen gas; but the production of theſe gaſes ſeemed to be owing to the air of the atmoſphere, and to the humidity of the charcoal employed to heat the apparatus, which had inſinuated themſelves through the pores of the earthen and porcelain veſſels. Theſe gaſes could be produced by making the porcelain tube red hot before the heat had been applied to the retort; and when an earthen retort was uſed the production of theſe gaſes continued, even after the ammoniac had all paſſed over, merely by continuing to heat the retort. *Ann. de Chem.* Tom. XI. p. 30.

This experiment of Clouet, with ſome ſlight variations, has been repeated ſucceſsfully at the Polytechnic School in Paris. In the firſt jar having a ſecurity tube, ſome diſtilled water was introduced, into the ſecond a ſaturated ſolution of ſulphat of iron, and into the third ſulphuric acid. In this experiment a glaſs, inſtead of a ſtone retort, was employed. The apparatus being properly arranged, the fire was applied to the retort. Carbonat of ammoniac was obſerved to paſs over into the jars, and a ſmell of ammoniac could be perceived as ſoon as the porcelain tube became hot. The operation was continued for ſome hours, but the liquors in the jars did not, upon trial, appear to contain any of the colouring principle. Suſpecting that this failure might be owing to the degree of heat that was uſed, the heat was ſuddenly increaſed, and this increaſed heat kept up for ſome time longer. Hydrogen gas was now diſengaged; and as ſoon as the firſt jar was ſaturated with the ammoniacal gas evolved, the iron in the ſecond began to be precipitated and to obſtruct the tube that was plunged into this jar. The gas of courſe began to eſcape by the ſecurity tube, and the peculiar ſmell of the colouring matter was immediately recogniſed. The tube having been cleared was replaced, and the precipitation continued to go on as before. The precipitate was at firſt of a brown colour, which gradually became darker till it became of a green colour, approaching to black. On putting an end to the operation, the laſt jar was found not to contain any colouring matter; but by adding muriatic acid to the precipitate in the ſecond, Pruſſian blue was immediately formed. The liquor in the firſt jar precipitated the ſolution of iron of a brown colour. An addition of this liquor rediſſolved the precipitate. The muriatic, nitric, and nitro-muriatic acids, equally produced the blue precipitate, whether they were mixed with the ſolution of iron, or poured on the precipitate.

The ſolution of potaſh, added to the liquor which had rediſſolved the precipitate of iron, took from it the colouring principle. By boiling the mixture, and filtering it, a pruſſiat of potaſh was obtained, which afforded a very beautiful Pruſſian blue with ſolutions of iron. Pruſſiat of potaſh was alſo obtained by boiling a little potaſh in the liquor from which the Pruſſian blue had been precipitated.

The ammoniac in the firſt jar contained a conſiderable quantity of the colouring matter, but in a very looſe ſtate of combination. See *Journ. de Poly.* p. 436.

i Dr. Prieſtley firſt obſerved that nitrous gas was abſorbed by a ſolution of ſulphat of iron, but it was reſerved for Humboldt and Vauquelin to explain the nature of the intereſting changes which take place during this abſorption. The nitrous gas employed in their experiments contained an admixture of 12 parts in the 100 of azotic gas. Of 252 cubic inches of this nitrous gas, introduced into a ſolution of an ounce and a half of ſulphat of iron, 180 inches were abſorbed. The 72 cubic inches of unabſorbed gas contained in all only 8,64 of azotic gas; ſo that about 11 parts in the hundred of this gas had been alſo abſorbed.

By adding to the ſolution, a ſolution of cauſtic potaſh, a precipitation of green oxyd of iron was produced, with an evident diſengagement of ammoniac. The addition of concentrated ſulphuric acid produced an immediate diſengagement of vapours evidently conſiſting of nitric acid in the elaſtic ſtate. The ſolution, therefore, muſt neceſſarily have contained a portion of nitrat of ammoniac. From conſidering the nature of the ingredients alſo, it becomes obvious, that the hydrogen neceſſary to form the ammoniac could only in this experiment have been derived from the decompoſition of a portion of water. Vauquelin conceives that no leſs than four forces muſt have concurred in the production of the nitric acid; 1ſt, That of the oxygen of the water for nitrous gas, by which the nitric acid was produced; 2d, That of the uncombined azot, and of the azot in the nitrous gas, for the hydrogen of the water by which the ammoniac was produced; 3d, That of the ſulphuric acid for ammoniac, by which the ſulphat of ammoniac was produced; and, 4thly, That of the nitric acid for the oxyd of iron, which gave birth to the nitrat of iron. *Ann. de Chem.* Tom. XXVIII. p. 181.

[k] Fluoric acid attacks the metal as well as the oxyd of iron. During its combination with the former, hydrogen gas is evolved. It appears from Rinman's experiments to be difficult to ſaturate the fluoric acid with iron. By boiling the ſolution a copious precipitation of the oxyd of iron is produced. Fluat of iron does not cryſtallize. It is decompoſed in the fire, and by alkalis and earths. It is decompoſed alſo by the ſulphuric, nitric, and muriatic acids.

The boracic acid, diluted with water, diſſolves both the metal and the oxyd of iron by the aſſiſtance of heat. The ſolution, which has the colour of amber, depoſites, by ſtanding, a yellow ochry precipitate, and, by evaporation, faſciculated yellowiſh cryſtals. If a ſolution of borax be mixed with a ſolution of ſulphat of iron, a borat of iron is formed, which is very difficultly ſoluble in water. This ſalt is decompoſed by alkalis, and by all the acids except the carbonic.

Liquid phoſphoric acid diſſolves iron in the heat with violence. During the ſolution an inflammable gas is diſengaged, which burns, like phoſphorus, with a blue flame. If the acid be not fully ſaturated with iron, the ſolution ſhoots into cryſtals, which remain unchanged in the air, but which melt in the fire into a garnet coloured glaſs. When the acid is fully ſaturated with iron a white precipitate is inſtantly formed, which is extremely inſoluble even in boiling water. This is the *ſyderit* of Bergman and other chemiſts.

Oxalat of iron, with an exceſs of acid, is eaſily ſoluble in water. According to Bergman, 100 parts of this ſalt conſiſt of 0,55 of acid and 0,45 of oxyd of iron. If the oxalic acid be ſaturated with the oxyd of iron, a whitiſh inſoluble precipitate is formed. This acid has the ſtrongeſt affinity of all the acids for iron.

The citric acid diſſolves iron readily with the evolution of hydrogen gas. The ſaturated ſolution is of a dark colour. With time it becomes muddy, black, and thick. This ſalt is but little known.

The malic acid diſſolves iron, according to Scheele, and forms with it a deliqueſcent ſalt.

The benzoic acid acts weakly on the metal, but more powerfully on the oxyd of iron. The ſolution affords cryſtals, which have a ſweetiſh taſte, and effloreſce in the air. Benzoat of iron is ſoluble in alcohol.

Succinic acid affords a ſlightly coloured ſolution by digeſtion with iron, and an ochry precipitate, the nature of which has not been inveſtigated.

During the ſolution of iron in liquid arſenic acid, hydrogen gas is diſengaged. Scheele remarks that this ſolution often forms into a jelly in open, but never in cloſe veſſels. Alkalis precipitate the arſeniat of iron of a greeniſh white colour, which becomes reddiſh by expoſure to a glow heat. If one part of iron filings be diſtilled with four of arſenic acid, a ſpontaneous inflammation is produced, by which the acid is converted into the oxyd and metal of arſenic. Arſenic acid precipitates the acetat of iron of a dark green. The neutral arſenical ſalts decompoſe all the acid ſolutions of iron. Arſeniat of iron is eaſily decompoſed by calcining it with charcoal. The arſenic acid has very little action on the oxyd of iron.

[l] Gold unites eaſily with on, and by this union becomes harder and leſs mal-

leable. In the proportion of ſix parts of gold to one of ſteel, the metallic mixture may be beat out into plates without cracking. Iron is only partially ſeparated by combuſtion in a glow heat. It has a ſtronger attraction than gold for the oxygenated muriatic and nitro-muriatic acids, and precipitates gold from theſe acids in its metallic ſtate.

Silver combines readily with iron. A mixture of 14 parts of ſilver, and 2½ of iron, is more elaſtic than ſilver, attracts the magnet, and is not decompoſed in a ſtrong fire. A ſmall portion of iron does not ſeem to injure the colour or malleability of the ſilver. Iron precipitates ſilver from all its ſolutions in acids. But this happens in the nitric only, when the acid is not completely ſaturated, or when nitrous gas is added. Muriat of ſilver is decompoſed in the dry way by diſtillation with iron filings.

Iron precipitates mercury in its metallic ſtate from its ſolution in acids. Diſtilled with oxygenated muriat of mercury the muriat is decompoſed, and fluid mercury produced. Sulphat of iron precipitates mercury from its ſolution in nitric acid in its metallic ſtate.

Lead is precipitated from its ſolutions in acids by iron.

Iron precipitates biſmuth from its acid ſolutions, and in the dry way takes from it the ſulphur which it contains.

Nickel has the ſtrongeſt affinity of all the metals for iron, and is ſeparated from it with the greateſt difficulty. The admixture of nickel does not injure the malleability of the iron, but rather ſeems to increaſe it. It renders the iron leſs fuſible. Nickel is precipitated only in a very imperfect manner by iron from its ſolutions in acids.

Iron unites in cloſe veſſels with arſenic. This combination renders the iron more brittle, and diminiſhes its attraction for the magnet. It is ſeparated from the iron with difficulty.

[m] The affinity of iron for carbon is ſo great, that in a high temperature it takes the carbon from carbonic acid. By putting iron, cut into ſmall pieces, into a crucible, along with equal parts of carbonat of lime and argil, and keeping them for an hour or more in the degree of heat neceſſary to weld iron, Clouet obtained a ſteel ſimilar to caſt ſteel. Morveau attributes the decompoſition of the carbonic acid, which took place in this proceſs, to the concurrence of the affinity of one portion of the iron for oxygen, and of the other for the carbon. And accordingly it happens, in this proceſs, that the green oxyd of iron is uniformly produced. The loſs of iron by oxydation, in this experiment, varied from about a twelfth to a twentieth part. Morveau ſuggeſts whether ſteel may not be obtained in this way containing always the ſame quantity of carbon? a condition ſo much to be wiſhed for in the manufacture of this ſubſtance.

[n] From the mean reſults of ſeveral experiments, Vauquelin concludes that the carbure of iron conſiſts of

Carbon, -	0,53
Iron, -	0,26
Silex, -	0,21

The preſence of the ſilex, however, that able chemiſt conſidered as merely accidental, and as varying according to the circumſtances in which the carbure of iron is formed. *Ann. de Chem.* Tom. XXII. p. 1.

CHAPTER XIX.

CONCERNING COPPER.

COPPER is a ductile metal, of a red brilliant colour, to which chemiſts have given the name of Venus, on account of the facility with which it unites to, and becomes changed by, a great number of bodies. It has a diſagreeable ſmell, which is more ſenſible when it is rubbed or heated; its taſte is ſtyptic and nauſeous, though leſs perceptible than that of iron; it is hard, elaſtic, and ſonorous, very ductile, and capable of being reduced into exceedingly thin leaves, or fine wire; by immerſion in water it loſes between one eighth and one ninth of its weight; its tenacity is ſuch, that a copper wire of the tenth of an inch in diameter, can ſuſtain a weight of 299¼ pounds before it breaks; its fracture appears compoſed of ſmall grains; it is ſuſceptible of a regular form; the Abbé Mongez deſcribes its cryſtals as quadrangular pyramids, ſometimes ſolid, and ſometimes compoſed of other ſimilar ſmall pyramids, laterally adhering.

Copper is found in the earth in various ſtates; its ores are very numerous, but may all be referred to the following:

1. Native copper having the red colour, the malleability, and all the other properties of this metal. It is diſtinguiſhed into two kinds, copper of the firſt formation, and copper of the ſecond formation, or of cementation. The copper of the firſt formation is diſperſed in laminæ, or fibres, in a gangue almoſt always quartzoſe; ſome of its cryſtals, of an octahedral form, and adhering laterally to each other, reſemble a kind of vegetation; other ſpecimens are in maſſes or grains. Copper of cementation is commonly in grains, or ſuperficial laminæ, on ſtones or on iron: this laſt appears to have been depoſited in waters, containing ſulphat of copper which has been precipitated by iron. Native copper is found in many parts of Europe; at St. Bell, in Lyons; at Norberg, in Sweden; at New-

fol, in Hungary; in Siberia, where it appears to be in very great abundance; and in ſeveral parts of America *.

2. Copper, oxydated and mineralized by the carbonic acid: there are ſeveral varieties of this native carbonat of copper.

Varieties.

A. Red copper, or *hepatic ore of copper*. This ore is known by its red duſky colour, ſimilar to that which is detached by the hammer from red hot copper. Monnet conſiders this ore as native oxyd of copper; it is uſually mixed with native copper and *mountain green*; it is rare, and ſometimes cryſtallized in octahedrons, or ſilky fibres, called *flowers of copper*.

B. *Earthy copper*, *mountain green*, or *green chryſocolla*. This ore is a true oxyd of copper, of a more or leſs deep green, not heavy, and unequally diſtributed in its gangue: it appears to be combined with the carbonic acid, according to the analyſis made by the Abbé Fontana of the malachite. It is ſometimes very pure, and is diſtinguiſhable into three ſtates.

1. *Simple mountain green*, earthy or impure, called likewiſe *green chyſocolla*.

2. Cryſtallized mountain green, or *ſilky copper ore of China*; this ore, which is common in the Hartz, is likewiſe found in China; it is very pure, and cryſtallized in long ſilky bundles, of conſiderable ſolidity. That of Siberia is very beautiful.

Mountain green in ſtalactites, or *malachite*; this ſubſtance is found frequently in Siberia, is compoſed of beds which repreſent nipples of various magnitudes; ſome ſpecimens are compoſed of needles, converging towards a common centre; the different layers have not the ſame ſhades of green. The grain of malachite is ſufficiently hard to receive a good poliſh, and is therefore worked into different toys; but as it is frequently porous, and full of unequal cavities, the ſolid pieces of a certain ſize are reckoned valuable.

C. *Mountain blue*, or *blue chryſocolla*. It is an oxyd of copper, of a deep blue colour, ſometimes regularly formed in rhomboidal priſmatic cryſtals of a fine blue; it is then called *azure of copper*. At other times it has the form of ſmall grains, diſpoſed in a cavity of different gangues, eſpecially quartz; it uſually conſtitutes ſuperficial layers in the cavities of the grey and yellow copper ores. All theſe oxyds of copper appear to have been precipitated from ſulphuric ſolutions of copper, by the intermedium of calcareous earths, through which the waters have tranſuded. Sage confirms theſe blue copper ores as combinations of copper with the ammoniac, from which he affirms they differ only in their leſs degree of ſolubility; he likewiſe thinks that the malachites is produced from this blue, which he calls tranſparent azure ore; but the greater number of mineralogiſts have not adopted this opinion. Morveau thinks that blue oxyd of copper does not differ from the green oxyd, but in the circumſtance of its being leſs oxydated.

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* And in various places in England, Scotland, and Wales. T.

The blue oxyd of copper colours certain ſtones, more eſpecially turquoiſe ſtone, in which Reaumur found copper, and the lapis armenius, whoſe baſe is calcareous carbonat, or ſulphat of lime. Mr. Kirwan reckons theſe blue ſtones as a ſpecies of copper ore. The turquoiſe ſtone is formed of the bones of animals, coloured by copper; thoſe of Perſia are not attacked by the nitric acid, according to Reaumur; but thoſe of Languedoc are completely ſoluble in that menſtruum.

3. Copper mineralized by the muriatic acid, and united to clay. Werner ſpeaks of this ore in his tranſlation of Cronſtedt; it has been confounded with talc, and a perſon of the name of Dans expoſed it to ſale in Paris in the year 1784, under the name of green mica; it conſiſts of ſmall beautifully green cryſtals, or ſmall brilliant ſcales. Foſter diſcovered it in the mines of John Georgenſtadt; the green cupreous ſand of Peru, which has been brought by Dombey, and in which analyſis has ſhown the exiſtence of a little muriatic acid, is perhaps referable to this ore.

4. Copper mineralized by ſulphur, with ſcarcely any iron. This is called by the very improper name of *vitreous copper ore*; it is of a deep violet grey, greeniſh brown, or liver colour; it

melts by a very gentle heat, is ponderous, ſometimes flexible, and always yields to the knife; in its fracture it appears brilliant like gold; it is one of the richeſt ores of copper, as it affords about ninety pounds of metal per hundred weight.

5. Copper mineralized by ſulphur, with more iron than the foregoing; azure copper ore; it does not differ from the preceding but in the quantity of iron, which ſometimes amounts to thirty pounds per quintal; it affords no more than fifty or ſixty pounds of copper per quintal, the reſt being ſulphur: theſe two ores are conveniently aſſayed by acids.

6. Copper mineralized by ſulphur, with much iron; brilliant or yellow pyrites. The quantity of ſulphur and copper varies greatly in this mineral, the iron is always very abundant. It forms veins in the earth. This ore is ſometimes maſſy, and of a dark colour; it often appears ſcaly, and, as it were, micaceous; in this form it is found in Denmark, Norway, Sweden, and St. Marie-aux-Mines, in France. Sometimes it is diſſeminated in its gangue, like the copper of Alſatia; and is then called *ſpotted ore of copper*: this variety is often mixed with a ſmall quantity of azure. The cupreous pyrites often preſent very brilliant blue, or violet colours at their ſurface, which are produced by the decompoſition of their principles: they are then called chatoyant ores of copper, or *peacock's tail ores;* they commonly contain a large quantity of ſulphur, a ſmall quantity of iron, and are not rich in copper. When theſe ores are only ſuperficially diſſeminated in their gangues, they are more particularly diſtinguiſhed by the name of *copper pyrites;* ſuch are the ores of Derbyſhire, in England; ſome of thoſe of St. Bell, in Lyons, and many ores of Alſatia, ſuch as thoſe of Caulenbach and Feldens; they adhere to every kind of gangue, rock cryſtal, quartzoſe ſpar, ſchiſtus, mica, &c.

7. Copper united to ſulphur, arſenic, iron, and a ſmall quantity of ſilver. This ore, called *arſenical copper ore*, or fahlertz, greatly reſembles the grey ſilver ore, being only ſomewhat leſs brilliant, and differs merely from that, in containing a leſs quantity of ſilver. Romé de Liſle likewiſe diſtinguiſhes a white copper ore, which contains, according to him, rather more ſilver than the grey, but it is in reality a ſilver ore. The

fahlertz commonly affords from thirty-five to ſixty pounds per quintal.

8. Copper mineralized by ſulphur and arſenic, with iron and zink, *brown or blendoſe copper ore.* Monnet found this ore only at Catharineberg in Bohemia; it is brown, granulated, and very hard, and contains from eighteen to thirty pounds of copper per quintal.

9. Schiſtoſe copper ore. This conſiſts of the *vitreous copper ore,* very intimately mixed in a brown or black ſhiſtus. It contains from ſix to ten pounds per quintal; chalk muſt be added in order to fuſe it.

10. Bituminous copper ore. This conſiſts of copper ore mixed with a kind of pit coal in Sweden.

11. Black copper ore, of the colour of pitch. Gellert denominates it *copper ore in ſcoriæ;* it is a reſidue of the decompoſition of the yellow and grey copper ores, which contain neither ſulphur nor arſenic, and approaches to the ſtate of *malachite;* it has a black ſhining appearance like pitch.

12. Copper united to ſulphur and arſenic, containing antimony: antimonial copper ore. Sage mentions this ore in his Elements of Mineralogy; it is grey and brilliant in its fracture, like antimony, and contains from fourteen to twenty pounds of copper in the quintal.

To aſſay an ore of copper, it muſt firſt be pounded and waſhed, and then roaſted for a long time by a ſtrong heat, and laſtly, melted with four times its weight of black flux and marine ſalt; the button, which is often rendered black by a remaining portion of ſulphur, muſt be melted with four parts of lead, and cupelled, in order to ſeparate the ſilver and gold it may contain; becauſe there are few copper ores which do not contain a certain quantity of theſe precious metals. The flux of Tillet, which is a mixture of two parts of pounded glaſs, with one of calcined borax, and one eighth of charcoal, ſucceeds better for theſe reductions than the black flux, becauſe the latter forms an alkaline ſulphure, which diſſolves part of the oxyd of copper.

Bergman adviſes the application of the ſulphuric and nitric acids in the aſſay of theſe ores by the humid way; when the copper is diſſolved by the acids, it is precipitated by iron.

In the large way, copper ores are pounded, waſhed, and roaſted in the open air, with ſcarcely any additional fuel, becauſe the ſulphur they contain burns of itſelf, as ſoon as it is well ſet on fire. When it is burnt out, the ore is roaſted once or twice more with wood, and is melted in an open fire, into the ſubſtance called a *mat of copper;* the mat conſiſts of copper which ſtill contains a portion of ſulphur: the fuſions it is ſubjected to ſerves to preſent new ſurfaces of the metal to the air, in order that it may be roaſted with great facility. After ſix or ſeven ſucceſſive roaſtings, according to the quantity of copper the ore may contain, it is at laſt fuſed into *black copper,* which, though malleable, ſtill contains a portion of ſulphur, which is not ſeparated but by the proceſs for the extraction of the perfect metals it contains. The black copper is fuſed with three times its weight of lead, which is called *refreſhing the copper,* and this mixture is caſt in moulds into the form of loaves, called *loaves of eliquation.* Theſe are placed on two plates of iron, inclined in ſuch a manner as to leave an opening between them at the bottom; the plates compoſe the upper part of the furnace of eliquation, whoſe bottom ſlopes forward; the fire made beneath the plates heats the loaves; the lead melts and flows down among the coals, carrying with it the ſilver and the gold, with which it has a ſtronger affinity than the copper. After this operation, which is termed *eliquation,* the loaves are found conſiderably diminiſhed in weight, and changed in figure; the heat is then raiſed, ſo that the copper may be nearly melted, in order that all the lead may be perfectly ſeparated. The lead containing the perfect metals is carried to the cuppelling furnace; and the copper is refined by melting in a crucible, where it remains a ſufficient time to throw up, in the form of ſcum, all foreign ſubſtances it may contain; it is examined from time to time, by immerſing iron rods in it, which become coloured with a ſmall quantity of copper, and its purity is judged of by the brilliant redneſs of theſe ſpecimens. Refined copper is caſt into plates, or into roſettes; to form a roſette, the ſcoriæ which cover the copper in fuſion, are carefully removed, and the ſurface of the metal is ſuffered to congeal. When it is no longer fluid, a wet broom is applied, the cold cauſes it to ſhrink, and a congealed portion of the metal not only detaches itſelf from the ſides of the crucible, but from the reſt of the melted metal, from which it is taken with tongs; the greateſt part of the copper is, by repeating this operation, converted into roſettes; the portion which remains at the bottom is called the *king*.

Cupreous pyrites, which contain but a ſmall portion of metal, are not worked but for the purpoſe of extracting ſulphur and *vitriol*. At St. Bell, and in many other places, they are roaſted, and expoſed to diſtillation to ſeparate the ſulphur. During the roaſting, a portion of the ſulphuric acid reacts on the metal, diſſolves it, and begins to form ſulphat of copper. The roaſted pyrites are afterwards expoſed to the air. When the *vitriolization* is finiſhed, the pyrites are lixiviated, and, by evaporation of the filtered liquor, a ſalt, in blue rhomboidal cryſtals, called *cupreous vitriol*, *blue vitriol*, *blue copperas*, *or Cyprian vitriol*, is obtained. We ſhall ſpeak of this ſalt among the combinations of this metal.

Copper, when heated, becomes coloured on its ſurface, nearly in the ſame manner as ſteel; the colours are blue, yellow, and laſtly, violet: it does not melt till it is ſtrongly ignited; when completely fuſed it appears covered with a green flame, boils, and is volatilized, as may be obſerved, in the chimneys of founderys [a]. Flowers of copper are likewiſe found in the melting pots. If this metal be projected through flame, in ſmall filings, it produces a blue and green colour, and from that property it is uſed in fire works. If the melted metal be ſuffered to cool ſlowly, and, after the ſurface is become congealed, the fluid portion be poured off, the remaining ſolid part is found to be cryſtallized in pyramids; which are more regular and large, in proportion as the fuſion has been more complete, and the cooling more gradual; its pyramids are quadrangular, and appear to be formed of a great number of octahedrons, inſerted one in the other.

Copper heated with acceſs of air, burns at its ſurface, and is converted into an oxyd of a dark red, in proportion as it abſorbs the baſe of vital air: this oxyd may be eaſily obtained by heating a ball of copper to redneſs, which cauſes the oxyd to ſcale off. The ſame effect takes place when red hot copper is quenched in cold water; the ſudden contraction of the parts of the metal, facilitating the ſeparation of the portion of oxyd which covers the ſurface: this oxyd falls to the bottom of the water, and is called *ſcales of copper.* As it is not perfectly oxydated, it may be burned afreſh in the muffel of the cupelling furnace; after which laſt proceſs it is found to be of a deep brown colour; but by a violent heat it melts into a maſs of a blackiſh or deep reddiſh brown colour. The oxyd of copper may be decompoſed, and deprived of the oxygen, which takes its metallic properties by oils, reſins, &c. The ſcoriæ are partly reducible without addition, for the founders, who buy them of the copperſmiths, take no other trouble with them than that of throwing them into large crucibles on the melted copper, with which they incorporate by fuſion; the ſame method is uſed to melt the filings. The oxyd of copper appears to poſſeſs ſome ſaline properties, but its nature has not yet been aſcertained.

The air attacks copper with greater or leſs facility, accordingly as the fluid is more or leſs loaded with moiſture, and converts it into a *ruſt*, or green oxyd, which appears to have ſome ſaline qualities, viz. taſte and ſolubility in water. From this circumſtance the ancient chemiſts admitted the exiſtence of a ſalt of copper. It is remarkable, that this *ruſt* never attacks copper, except at the ſurface, and ſeems even to contribute to the preſervation of the internal parts and maſſes of this metal, as may be ſeen in antique medals and ſtatues, which are preſerved very well beneath a covering of ruſt. The antiquarians call this cruſt *patina*, and ſet a high value on it, becauſe it ſhows the antiquity of the pieces, which are covered with it. Many artiſts, and in particular the Italians, know how to imitate this coating, and to counterfeit the antique bronzes.

The oxydation of copper by humid air, appears to be produced by water in the ſtate of extreme diviſion; this fluid however does not appear to attack copper, nor decompoſe it like iron, at a high temperature. This metal ſeems to be more oxydifiable by cold water; it being a well known fact, that more danger attends the ſuffering of fluids to cool in copper veſſels, than in making them boil; becauſe, as long as the fluid is boiling, and the veſſel hot, the aqueous vapour does not adhere to its ſurface; but when the veſſel is cold, the drops of water which adhere to its ſides ſeem to reduce it into green oxyd. It is to the air and the carbonic acid diſtributed therein we muſt attribute this oxydation; for by diſtilling this ruſt of copper in the pneumato-chemical apparatus, I have obtained carbonic acid.

Copper does not unite with earthy matters; its oxyd facilitates their fuſion, and forms with them glaſſes of a deep brown.

Barytes, magneſia, and lime, have no evident action on copper, and the action of theſe ſubſtances on the oxyds of that metal is not known.

Cauſtic fixed alkalis digeſted in the cold with copper filings aſſume, at the end of a certain time, a light blue colour, the copper becoming covered with a powder of the ſame colour; theſe ſolutions are better effected in the cold than by the aſſiſtance of heat, according to Monnet. It is nevertheleſs eſſential to be obſerved, that this chemiſt made uſe of carbonat of potaſh inſtead of pure fixed alkali, which laſt appears to have a much ſtronger action on copper. But neither the one nor the other of theſe ſalts does any thing more than favour and accelerate the precipitation of atmoſpheric oxygen upon the copper, for this oxydation of the metal does not take place without the contact of air.

This fact is more eſpecially remarkable in the action of ammoniac, which diſſolves copper with conſiderable rapidity. This ſalt, digeſted upon copper filings with the contact of air, produces, at the end of a few hours, a deep and moſt beautiful blue; the quantity of copper taken up is very inconſiderable. I have obſerved the phenomena of this ſolution for the ſpace of a year. In a ſmall bottle cauſtic ammoniac was poured on filings of copper, the bottle was frequently opened; at the end of ſeveral months the ſurface of the metal was covered with a blue oxyd; the ſides of the bottle were covered with an oxyd of a pale blue, and the lower part of the bottle which contained the copper, exhibited on the ſurface of the glaſs a brown oxyd, whoſe upper part was yellowiſh: this liquor loſes its colour almoſt entirely when kept cloſe, but it re-appears again when the bottle is opened. This phenomenon does not appear in a very evident manner, excepting at firſt, and when the ſolution is decanted from the copper; if the ſolution be old, and the copper ſtill remains in it, its colour is of a beautiful blue, though in cloſed veſſels; but on expoſure to air it becomes deeper. We manifeſtly ſee the influence of atmoſpheric oxygen in theſe phenomena.

By ſlowly evaporating the ſolution of copper by ammoniac in the fire, the greateſt part of this ſalt is diſſipated, a portion remains fixed with the oxyd of the metal, and is depoſited in the form of ſoft cryſtals, as Monnet has obſerved. Sage affirms, that very beautiful cryſtals may be obtained by a ſlow evaporation, and has compared them to the natural azure of copper. The latter ſubſtance does not, however, afford ammoniac when heated; is inſoluble in water, and does not effloreſce in the air like that prepared by art. Baumé affirms, that this compound affords very brilliant cryſtals, of a beautiful blue. The ſolution expoſed to the air dries quickly, and leaves a graſs green ſubſtance, which is merely a green oxyd of copper. Sage thinks that malachite is thus produced. But this oxyd does not afford carbonic acid, as the earthy ore of copper does. If an acid be poured into the ſolution of copper by liquid ammoniac, no precipitate is formed, but the blue colour diſappears totally, and becomes converted into a very pale green. This phenomenon, which has been obſerved by Pott and Monnet, ſhows that the quantity of oxyd of copper in ammoniac is very ſmall, and that it is re-diſſolved by the acid, or by the ammoniacal ſalt, formed by the addition of the acid. The blue colour may, however, be made to appear again, by the addition of ammoniac to the mixture. The oxyd of copper formed by fire, and every other oxyd of this metal, diſſolves immediately in pure ammoniac, which by this means may be made to take up a good quantity of the metal; a moſt beautiful colour being at the ſame time produced. From this property the ammoniac has been propoſed as a teſt to diſcover the ſmalleſt portion of copper in all matters in which its exiſtence may be ſuſpected. The oxyd of ammoniacal copper, or ammoniac united to the oxyd of this metal, is decompoſed into its two component principles, by expoſure to a ſtrong heat; the oxygen quits the copper to unite with the hydrogen of the ammoniac, with which it forms water, the copper paſſes again to the metallic ſtate, and the azot, the other principle of ammoniac, is diſengaged in the gazeous form. This is one of the experiments which conducted Berthollet to the diſcovery of the compoſition of ammoniac. A ſmall quantity of nitric acid alſo appears to be formed by the union of the azot of the ammoniac with a portion of the oxygen of the copper.

The ſulphuric acid does not act on copper but when concentrated and boiling; much ſulphureous acid gas is diſengaged during the ſolution. A brown matter, of the conſiſtence of a thick fluid, containing oxyd of copper, and a portion of the oxyd combined with the ſulphuric acid, are found at the bottom; from which, by the addition of water and filtration, a blue ſolution is obtained: if this be evaporated to a certain point, and ſuffered to cool, rhomboidal long cryſtals are afforded, of a beautiful blue colour, called ſulphat of copper: if the ſolution, inſtead of being evaporated, be left expoſed a long time to the air, it affords cryſtals; but a green oxyd is precipitated. All the oxyds of copper when formed or dried in the air, are of this colour.

Sulphat of copper has a very ſtrong ſtyptic taſte, approaching even to cauſticity; when expoſed to heat it very ſoon melts, loſes its water of cryſtallization, and becomes of a blueiſh white; a ſtrong heat is required to ſeparate the ſulphuric acid, which adheres much more ſtrongly to the oxyd of copper than to that of iron, though the iron indeed decompoſes the ſolutions of copper by a different attraction, that of the iron for oxygen. Sulphat of copper is decompoſed by magneſia and by lime; the precipitate formed by either of theſe ſubſtances is of a blueiſh white, but becomes green if dried by expoſure to air. Hence ſome chemiſts affirm, that the precipitates of ſulphat of copper are green: the ſame is true of the precipitates obtained by fixed alkalis in the different ſtates, being firſt blueiſh, and aſſuming a green colour as they dry; *mountain green* may perhaps be formed in this manner. We muſt obſerve, that when ſulphat of copper is precipitated by the ſolution of carbonat of potaſh, no efferveſcence is excited, which is a proof that the carbonic acid unites readily with the oxyd of copper. All metallic ſolutions do not exhibit this phenomenon. Ammoniac precipitates the ſolution of ſulphat of copper in the ſame manner, of a blueiſh white colour; but the mixture very ſoon aſſumes a deep blue colour, becauſe the ammoniac diſſolves the precipitate. A very ſmall quantity of this ſalt is ſufficient to re-diſſolve all the oxyd of the copper ſeparated from the ſulphuric acid.

The nitric acid diſſolves copper with great rapidity in the cold; a large quantity of very red nitrous gas being at the ſame time diſengaged. This is the method uſed by Dr. Prieſtley to obtain a very ſtrong nitrous gas. A portion of the metal reduced to the ſtate of oxyd is precipitated in the form of a brown powder, and is ſeparated by the filter. The filtrated ſolution is of a much deeper blue than the ſulphuric ſolution, which ſhows that the copper is more perfectly oxydated; by previous and careful evaporation, cryſtals may be obtained in cooling. Macquer is one of the firſt chemiſts who obſerved this property, in his Memoir on the ſolubility of ſalts in ſpirit of wine. If its cryſtals be formed very ſlowly, they have the figure of long parallelograms; if more quickly depoſited, they are hexahedral priſms, with an obtuſe point, irregularly diſpoſed, and reſembling bundles of divergent needles. Laſtly, If this ſolution be too much evaporated, it affords only a magma, of an irregular form; which doubtleſs occaſioned certain chemiſts to aſſert, that the ſolution was not ſuſceptible of cryſtallization. Nitrat of copper is of a very bright blue, and is ſo cauſtic, that it may be employed in corroding the excreſcences which ariſe on the ſkin; it melts, according to Sage, at the temperature of twenty degrees of the thermometer of Reaumur, and detonates on burning coals, though this phenomenon is ſcarcely ſenſible, on account of the large quantity of water it contains. When melted in a crucible it emits large quantities of nitrous vapour, which may be collected by diſtillation; when dried, its colour is green; an increaſe of the heat converts it to a brown, in which ſtate it is a pure oxyd of copper. I have diſtilled this ſalt with the pneumato-chemical apparatus, and obtained much nitrous gas, a ſmall quantity of carbonic acid, and a ſmall quantity of vital air; it was converted into a brown oxyd by this operation. Nitrat of copper attracts the moiſture of the air, but it may be preſerved a long time in cloſe veſſels. In a dry and hot air it becomes covered with a green efflorefcence. It is very ſoluble in water, and rather more ſo in hot than in cold water. The ſolution expoſed to the air in ſhallow veſſels, or quickly evaporated in hot and dry weather, leaves an oxyd of the ſame green colour as the cryſtals of the ſalt have in ſimilar circumſtances. It is precipitated by lime, and is then of a pale blue colour; by fixed alkalis of a pale blueiſh white; by ammoniac in flocks of the ſame colour, which are very quickly re-diſſolved, and produce a brilliant deep blue colour in the liquor; by alkaline ſulphures of a reddiſh brown colour, without an hepatic ſmell; and by tincture of nut-galls, of an olive green. The ſulphuric acid likewiſe diſſolves nitrat of copper, and blue cryſtals of ſulphat of copper are obtained, if the acid be uſed in a very concentrated ſtate. Stahl obſerved this decompoſition: Monnet has ſince confirmed it, and I have ſeveral times had occaſion to make the ſame obſervation. Iron has a ſtronger affinity with moſt acids than copper. When a plate of iron is plunged in a ſolution of copper by acids, and in particular by the nitric acid, the copper is precipitated in the metallic form, and covers the ſurface of the iron; this precipitation depends on the ſtronger affinity of the iron than of the copper to oxygen. The ſulphat of copper exhibits the ſame phenomenon, and this proceſs has been uſed by impoſtors to make the credulous believe they were able to convert iron into copper.

The muriatic acid does not diſſolve copper, unleſs it be concentrated and boiling. Only a ſmall quantity of hydrogen gas is diſengaged during this ſolution. The muriatic acid aſſumes a very deep and almoſt brown colour; the combination forms a magma very ſoluble in water; if it be lixiviated, the water becomes of a beautiful green colour, which diſtinguiſhes this ſolution from the two foregoing; when ſlowly and cautiouſly evaporated, and ſuffered to cool, it depoſits priſmatic cryſtals of a regular form; on the contrary, if the evaporation has been too rapid, and the cooling too ſudden, it preſents only very ſmall ſharp needles.

The muriat of copper is of a very agreeable graſs green colour, its taſte is cauſtic, and very aſtringent, and it melts by a gentle heat, congealing again into a maſs when ſuffered to cool. Monnet affirms, that the muriatic acid adheres very ſtrongly to it, and that it cannot be volatilized without the aſſiſtance of a conſiderable heat. It ſtrongly attracts the moiſture of the air, and is decompoſable by the ſame intermediums as the preceding ſalts of copper. I have obſerved, that ammoniac does not diſſolve the oxyd of copper ſeparated from the muriatic acid, ſo well as that which is ſeparated from the ſulphat and nitrat of copper. Its blue colour is not ſo lively, and a portion of this oxyd not completely ſoluble, remains which appears to be in a higher degree of oxydation in this ſolution than in the others. The ſulphuric and nitric acids do not decompoſe the muriat of copper. The nitric ſolutions of mercury and ſilver decompoſe it by double affinity, a white precipitate being formed by the tranſpoſition of the muriatic acid to the oxyd of mercury or of the ſilver, and by the union of the oxyd of copper to the nitric acid. I have, however, obſerved, that the liquor does not aſſume a blue colour, which the ſolution of copper by the nitric acid ought to have; and that in general the oxyd of copper formed by the muriatic acid does not take this colour but with difficulty, as we have already obſerved with reſpect to ammoniac. It ſeems to me, in general, that the oxyds of copper paſs very eaſily from blue to green, but difficultly from green to blue. The muriatic acid diſſolves the oxyd of copper with much more facility than copper itſelf. This fact has been well obſerved by Brandt. The ſolution is of a fine green, and cryſtallizes as eaſily as the former, which proves, that, in the ſaline combinations of metals, the latter are always in the ſtate of oxyds, as we have already obſerved[b].

Nitre detonates difficultly by the addition of copper; the ſalt muſt be melted, and the copper very hot, in order that the deflagration may take place, otherwiſe it is very feeble. This operation is made by throwing filings of copper on nitre in fuſion in a large crucible, in order that the contact may be ſufficiently large. When the metal is ſtrongly heated, a ſlight motion, accompanied with ſmall flaſhes, is obſerved: the reſidue is an oxyd of a browniſh grey, mixed with potaſh. This being waſhed, the water ſeizes the alkali, which retains a ſmall quantity of copper, and the oxyd of the metal remains pure. It flows without addition into a glaſs of a deep opake brown, uſed in colouring enamels; the alkali is thought to be rendered cauſtic, but no experiments on this ſubject have yet been made with ſufficient accuracy.

Copper decompoſes muriat of ammoniac very readily. Bucquet, who examined this decompoſition with great care, obtained by the pneumato-chemical apparatus over mercury, from two drachms of copper filings, and one drachm of ammoniacal muriat, fifty-eight inches of elaſtic fluid, of which twenty-ſix inches conſiſted of very pure ammoniac gas, twenty-ſix of detonating inflammable gas, and ſix of mephitical gas, which extinguiſhed candles without being abſorbed with water, and without precipitating lime water. The azotic gas is a product of the decompoſition of a portion of liquid ammoniac. A ſmall quantity of liquid ammoniac is diſengaged, which ſwims over the mercury. The reſidue was a maſs of a blackiſh green, of which half was diſſolved by the water, and communicated to it a green colour, which is a diſtinctive character of the muriat of copper; the other half exhibited a kind of brown oxyd of copper, formed by the water of the ammoniacal muriat. When this decompoſition was repeated in the doſe of four ounces of copper with two ounces of ammoniacal muriat, in the common apparatus, Bucquet obtained two drachms eighteen grains of blue liquid ammoniac, which effervefced a little with acids, and contained about one cubic inch of carbonic acid in the drachm. This chemiſt was at a loſs to determine whence the latter gas was produced, but I think it may ariſe from ſome impurities in the ſal-ammoniac; for having repeated this experiment with ammoniacal muriat purified by ſublimation, I obtained a very cauſtic ammoniac, which did not at all efferveſce with acids. The oxyd of copper likewiſe decompoſes ammoniacal muriat, and affords a portion of carbonic acid, together with the ammoniac it diſengages, which renders the latter efferveſcent. This alkali is always blue, becauſe it carries up with it a ſmall portion of the oxyd of copper, to which its colour is owing. Acids do not however precipitate this metal. Two medicines are prepared in pharmacy with ammoniacal muriat and copper, of which the firſt has received the name of *cupreous ammoniacal flowers*, or *ens veneris*, and is nothing more than ammoniacal muriat coloured by a ſmall portion of oxyd of copper. A mixture of eight ounces of this ſalt with one drachm of the oxyd of copper, is ſublimed in two earthen veſſels, the one placed on the other: all the ammoniacal muriat is volatilized without being decompoſed, and carries up a ſmall quantity of oxyd of copper, which gives it a blueiſh colour. The ſecond, which is called *aqua celeſtis*, is prepared by ſuffering a pound of lime-water and an ounce of ammoniacal muriat to remain in a copper veſſel for ten or twelve hours; the lime diſengages the ammoniac, which diſſolves a ſmall quantity of copper of the baſon, and produces the blue colour. The *celeſtial water* may be made in a glaſs or earthen veſſel, if a ſmall quantity of filings, or oxyd of copper, be added to the lime-water and ammoniacal muriat.

Copper appears to decompoſe ſulphat of alumine; for if a ſolution of this ſalt be boiled in a copper veſſel, a ſmall quantity of alumine is depoſited; and when the alumine is precipitated by ammoniac, its earth aſſumes a ſlight blue colour, denoting the preſence of copper. This effect may likewiſe be attributed to the ſmall exceſs of acid which ſulphat of alumine always contains [c].

Hydrogen gas does not act on copper, but reduces its oxyds, by depriving them of the oxygen, with which this gas has a ſtronger affinity than copper.

This metal unites very readily with ſulphur; the combination may be made in the humid way, that is to ſay, by mixing flowers of ſulphur and copper filings together, with a ſmall quantity of water; but it ſucceeds much better in the dry way. A mixture of equal parts of ſulphur in powder and copper filings, are put into a crucible, which is heated by degrees till it becomes red hot; the reſult is a maſs of a blackiſh grey, a ſort of *mat* of copper, which is brittle and more fuſible than the copper itſelf. This compound is prepared for dying and painting on calicoes, by placing ſtrata of plates of copper and ſulphur in powder in a crucible, and heating it gradually, as we have obſerved. The kind of mat which is produced, is pulverized, and called *æs veneris*. Alkaline ſulphures, and ſulphurated hydrogen gas, have a ſtrong action on copper: the former diſſolves the metal by the dry, as well as by the humid way; the ſecond ſtrongly colours the ſurface, but its effect has not yet been well examined into [d].

Copper forms alloys with many metals; with arſenic it becomes white and brittle, and forms *white tombac;* it unites with biſmuth, and, according to Gellert, forms an alloy of a reddiſh white, with cubic facets [e].

It unites very readily with antimony, and affords a *cupreous regulus*, which is diſtinguiſhed by a beautiful violet colour; it likewiſe decompoſes ſulphure of antimony, and unites with the ſulphur which it takes from the antimony.

It combines very readily with zink. This combination may be made in two ways. Firſt by fuſion; a metal is produced whoſe colour reſembles that of gold, and which is much leſs ſuſceptible of ruſt than copper, though leſs ductile than that metal: the nearer its colour approaches to that of gold, the more brittle it is; and it varies greatly according to the proportion of the mixture, and the precautions uſed in melting it; its varieties are, Similor, Pinchbeck, Princes-metal, and Manheim gold. Secondly, by cementing plates of copper with native oxyd of zink, or lapis calaminaris reduced to powder, and mixed with charcoal; in a red heat, the copper unites with the zink, and forms *braſs:* this is leſs ſuſceptible of ruſt than copper, and is likewiſe more fuſible, and leſs malleable. But a ſtrong heat, continued for a ſhort time, deprives it of the zink with which it was united, and converts it into copper again [f].

Copper unites difficultly with mercury; though a ſort of amalgam may be produced, by triturating copper in very thin leaves with mercury. A plate of this metal plunged in a ſolution of mercury by an acid, becomes coated over with a beautiful colour of ſilver, owing to the mercury which has been reduced and precipitated by the copper, and which has a greater affinity with oxygen than mercury has [g].

Copper and lead unite very eaſily by fuſion, as the formation of the leaves of eliquation prove [h].

Copper is combined with tin in two ways, either by applying melted tin on copper, or melting both metals together. The firſt operation is uſed in the tinning of copper, the ſecond forms bronze. To tin copper veſſels, they are firſt ſcraped, in order to render their ſurface clean and brilliant; after which they are rubbed with ammoniacal muriat, to clean them more perfectly. They are then heated, and ſprinkled with powdered reſin; this ſubſtance covering the ſurface of the copper, prevents its oxydation. Laſtly, the melted tin is poured on, and ſpread about. It is with juſtice complained, that the tinning of copper veſſels is not ſufficient to defend them from the action of air, moiſture, and ſaline ſubſtances, becauſe theſe veſſels are frequently obſerved to be covered with verdigriſe. It might be poſſible to remedy this inconvenience by a thick covering of tin, if there were not reaſon to fear, that a degree of heat ſuperior to that of boiling water, to which theſe veſſels are often expoſed, would melt the tin, and leave the ſurface of the copper uncovered. To prevent this laſt accident, the tin may be alloyed with iron, ſilver, or platina, to diminiſh its fuſibility, and render it capable of being applied in thicker ſtrata on the copper. Alloys of this kind are already uſed in ſeveral manufactures. The very ſmall quantity of tin required to cover the ſurface of copper, is ſurpriſing. Bayen and Charlard having determined, that a veſſel of nine inches in diameter, and three inches three lines in depth, did not gain more than twenty-one grains by tinning. This ſmall quantity is nevertheleſs ſufficient to prevent the dangers which might ariſe from the uſe of copper veſſels, provided care be taken that ſubſtances capable of diſſolving the tin be not ſuffered to remain too long a time in the veſſels; and more eſpecially that the tin be frequently renewed: as the friction, heat, and action of ſpoons, with which the included ſubſtances are ſtirred, deſtroy it very quickly. There is likewiſe another cauſe of apprehenſion reſpecting the tin uſed by braziers in tinning, &c. It is often alloyed with one fourth of its weight of lead; and in this caſe the bad effects of the latter metal are much to be feared, as it is known to be very ſoluble in acids and fat ſubſtances. It is therefore neceſſary that government ſhould take ſufficient care that the braziers be not deceived in the tin they purchaſe, and that they may not employ any but the Mallacca or Banca tin, in the ſtate it is received in from the Indies, without having been alloyed or re-melted by the pewterers.

La Folie, citizen of Rouen, well known by his chemical labours reſpecting the arts, and the uſeful diſcoveries with which he has enriched the art of dying, of pottery, and a great number of manufactures at Rouen, propoſed, in order to avoid the inconvenience and danger of tinning copper, that ſaucepans of forged iron, covered with zink, might be uſed, which, as we have already ſeen, is not productive of any dangerous effects. Many perſons have already uſed theſe veſſels, and have been ſenſible of their advantages. It is much to be deſired that the uſe of theſe veſſels may become more general.

When tin is melted with copper, a metal ſpecifically heavier than the two metals employed is obtained. This alloy is whiter, more brittle, and more ſonorous, in proportion as the quantity of tin is greater. When it is very white, it is called *bell-metal;* when it contains a large proportion of copper, it is yellow, and is called *bronze*. This laſt is uſed in caſting ſtatues, and forming pieces of artillery, which require to be ſufficiently ſolid not to burſt, and not ſo ductile as to have their form deſtroyed by the ſtroke of bullets.

Copper and iron are capable of uniting either by fuſion, or in the way of ſoldering; yet this combination does not eaſily ſucceed. When a mixture of the two metals is melted in a crucible, the iron is found in pieces in the copper, without being perfectly united. Copper decompoſes, according to Monnet, the mother water of ſulphat of iron, though iron has a ſtronger affinity with acids than copper.

The uſes of copper are numerous, and well known. The alloy of copper and zink is moſt commonly uſed on account of its great ductility and its beauty. As copper is a very violent poiſon, it ought never to be adminiſtered in medicine. The propereſt remedies in caſe of poiſoning by copper reduced into oxyd or verdegriſe, are emetics, abundance of water, alkaline ſulphures, alkalis, &c.

NOTES ON CHAPTER XIX.

COPPER.

a Copper is ſaid to require a heat equal to 1450° of Fahrenheit's ſcale for its fuſion.

b Fluoric acid diſſolves copper, and ſtill more readily its oxyd. The blue gelatinous ſolution which it forms affords cryſtals of a blue colour, and cubical ſhape. The affinity of this acid for copper is not known.

Boracic acid has little action directly on copper in the moiſt way; but if a ſolution of borax be added to a ſolution of ſulphat of copper, a pale green coloured ſalt is precipitated, which is difficultly ſoluble in water, but which, in the fire, melts into a greeniſh glaſs. The affinity of this acid is alſo undetermined.

Phoſphoric acid diſſolves only a ſmall portion of copper, but it acts more powerfully on the oxyd. The ſolution affords, by evaporation, a green tranſparent gum-like maſs, which melts into a dark opake glaſs in the fire. The affinity of this acid for copper is ſtill very undetermined.

The tartarit of copper is decompoſed in the fire. Tartaric acid produces a ſlow precipitation of copper from its ſolution in ſulphuric, nitric, and muriatic acids.

The citrat and malat of copper are but little known.

Benzoic acid diſſolves the oxyd of copper, and the ſolution ſhoots into dark-green coloured ſmall pointed cryſtals, which are difficultly ſoluble in water, and effloreſce a little in the air. This ſalt is decompoſed in the fire.

Succinic acid forms a ſalt with copper, which exiſts in the form of ſmall greeniſh cryſtals.

Water, impregnated with carbonic acid, diſſolves the oxyd of copper; but carbonat of copper is moſt eaſily obtained in the way of double affinity, by adding a ſolution of carbonat of potaſh to an acid ſolution of copper. The ſalt formed is of a lively green colour, is inſoluble in water, and weighs 94 per cent. more than the copper from which it was obtained.

Pruſſiat of potaſh precipitates copper of a yellowiſh green colour from its ſolution in nitric acid; but the precipitate becomes afterwards of a brown red, and, by drying, of an almoſt black colour.

The gallic acid precipitates copper from the ſulphuric acid, of a yellow colour.

c If finely pulverized chalk be added to a ſolution of ſulphat of copper, the ſulphat of lime falls along with the carbonat of copper, and forms with the pale green coloured paint commonly called *mountain green*. Pelletier directs this ſubſtance to be prepared in the following manner. Pulverized chalk, or carbonat of lime, is to be added to a ſolution of copper in diluted nitric acid. During the addition, the mixture is to be well ſtirred. The green precipitate which is formed is to be waſhed and triturated on a ſmooth ſtone, or in a large mortar. During trituration, from 7 to 10 parts of unſlaked lime are ſtill to be added to the precipitate. If the mixture be too dry, ſome water muſt be added, to give it the proper degree of conſiſtence for trituration. *Ann. de Chem.* Tom. XII. p. 67.

[d] Copper unites eaſily with phoſphorus, and is rendered more fuſible by this union. The phoſphure burns in a ſtrong fire, but remains in combination with the copper in the ſtate of an acid.

[e] Copper has a nearer affinity for acids than biſmuth. It takes ſulphur from biſmuth in the dry way.

[f] To ſeparate copper from the zink in braſs, Vauquelin recommends the following proceſs. Cauſtic potaſh is to be added to a ſolution of braſs in nitric acid, till there be an evident exceſs of the alkali. The mixture is to be immediately agitated, and the external air carefully excluded. After ſome minutes, the mixture is to be poured on the filter. The zink which is now diſſolved in the potaſh paſſes through the filter, and the oxyd of copper remains above it. This precipitate is to be waſhed till the water coming from it has no longer any taſte. It is then to be dried with a gentle heat, and weighed. The quantity of copper is to be eſtimated at 35 per cent. leſs than the weight of the maſs obtained; for 100 parts of the oxyd of copper contain 35 of oxygen. The external air is to be excluded from the mixture, in order to prevent the potaſh from abſorbing carbonic acid, which would occaſion a precipitation of a portion of the oxyd of zink. An inconceivably ſmall quantity of copper remains after this proceſs in the potaſh, diſſolved, not as might be imagined by the potaſh, but by a ſmall quantity of ammoniac, which is formed during the ſolution of zink in the nitric acid.

Vauquelin propoſes alſo to effect this ſeparation in a manner ſtill more ſimple, by diſſolving a determined quantity of braſs in concentrated ſulphuric acid, and by ſuſpending in the ſolution a plate of zink. The copper will be immediately precipitated in its metallic ſtate. When the precipitation has ceaſed, the liquor is to be decanted off, and the copper waſhed, dried, and weighed.

Ann. de Chem. Tom. XXXVIII. p. 40. See alſo a Memoir on the ſame ſubject, by *Deze*, *Journ. de Phyſ. Pluvioſe*, *Ann.* VII. p. 173. *Journ. de Phyſ.* Tom. I. *Nivoſe. Ann.* II. p. 60.

[g] If copper filings and cinnabar be diſtilled together, the cinnabar will be decompoſed, mercury paſs over into the receiver, and the copper remain in combination with the ſulphur in the retort.

[h] This compoſition is not permanent in the fire; for the lead melts, and abandons the copper. The reſpective affinities of lead and copper for acids have not yet been accurately determined.

CHAPTER XX.

CONCERNING SILVER.

Silver, called *Luna* or *Diana* by the alchemiſts, is a perfect metal of a white colour, and of the moſt lively brilliancy; it has neither taſte nor ſmell; its ſpecific gravity is ſuch, that it loſes about the eleventh part of its weight by immerſion in water, and a cubic foot of this metal weighs 720 pounds [a]. Silver is ſo ductile, that it may be beat into exceedingly thin leaves, and drawn into wire much finer than a hair *. A grain of ſilver may be extended ſo as to form a veſſel capable of containing an ounce of water. Its tenacity is ſo conſiderable, that a ſilver wire of the tenth of an inch in diameter, may ſuſtain a weight of 270 pounds without breaking. Its hardneſs and elaſticity are not equal to thoſe of copper. It is the moſt ſonorous of metals after thoſe we have mentioned. It hardens under the hammer, but very readily loſes that hardneſs by heating. Tillet and Mongez have cryſtallized this metal, and obtained quadrangular pyramids, ſometimes inſulated like thoſe which are found on the edges of the crucibles in which this metal has been melted, or grouped and laterally placed one on the other.

Silver is found in many various ſtates in nature; the principal ores of this metal may be reduced to the following:

1. Native or virgin ſilver; it is known by its brilliancy and ductility, and is found in a great variety of forms; it is often in irregular maſſes, more or leſs conſiderable in magnitude. Sometimes it has the form of capillary threads twiſted round, and in this ſtate ſeems to have been produced by the decompoſition of a red ſilver ore, as Henckel and Romé de Liſle have obſerved. It is likewiſe found in plates, and in forms which

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* A grain of leaf ſilver meaſures ſomewhat more than 51 ſquare inches, and the ſilver wire, uſed by aſtronomers, about the $\frac{1}{750}$ of an inch in diameter. This is about half the diameter of a fine human hair. T.

reſemble the webs of ſpiders, and which the Spaniards for that reaſon call *arane;* in vegetation, or branches formed by octahedrons, inſerted one in the other. Some of theſe ſpecimens exhibit the mark of a leaf of fern, others are cubes and ſingle octahedrons, whoſe angles are truncated; the latter are rare. Native ſilver is often diſperſed in a quartzoſe gangue, and is ſometimes met with in fat earths; it is found in Peru, in Mexico, and Kongſberg in Norway, at Johan Georgenſtadt, and at Ehrenfriedenſdorf in Saxony, at St. Marie, at Allemont in Dauphiny, &c. This metal is not naturally found in the ſtate of oxyd.

2. Native ſilver united to gold, copper, iron, arſenic, antimony, or to gold and copper together, or to arſenic and iron together. Theſe varieties of native ſilver alloyed are found at Freyberg in Saxony, and in the mines of Guadalcanal in Spain; but it muſt be obſerved that the foreign ſubſtances compoſe but a ſmall proportion.

3. The *vitreous ſilver ore* is compoſed, according to moſt mineralogiſts, of ſilver and ſulphur; it is of a blackiſh grey colour, reſembling lead; ſome ſpecimens are brown, greeniſh, yellowiſh, &c.; and it may be cut with the knife. It is often amorphous, ſometimes cryſtallized in octahedrons, in cubes or cubo-octahedrons, that is to ſay, into cubes, whoſe angles are truncated. Theſe laſt form the tranſition from the octahedron to the cube. Monnet diſtinguiſhes a variety, which, inſtead of yielding to the knife like the others, became reduced into powder. This ore affords from ſixty-two to eighty-four pounds of ſilver per quintal. It is very eaſily melted. If it be expoſed to a heat not ſufficient to melt it, the ſulphur is diſſipated, and virgin ſilver in vegetation or fibres is obtained.

4. The *red ſilver ore* is often of a deep colour, ſometimes tranſparent, cryſtallized in tubes, whoſe edges are truncated, or in hexahedral priſms, terminated by tetrahedral pyramids; at Potoſi it is called *Roſſi-clero.* The ſilver is combined with ſulphur and arſenic. When it is broken, its colour appears lighter within, and its ſtructure reſembles ſmall needles, or convergent priſms, like ſtalactites. If it be expoſed to a fire carefully managed, and capable of igniting it, the ſilver is reduced, and forms capillary vegetations, ſimilar to native ſilver.

It affords from fifty-eight to ſixty-two pounds of ſilver per quintal. The varieties of this ſpecies differ in colour, in form, in weight, &c. They are in general found in all places where the other ores of ſilver are met with.

5. Silver with arſenic, cobalt, and iron mineralized by ſulphur. Bergman affirms, that the ſilver is ſometimes $\frac{50}{100}$ in this ore. The ore is ſometimes grey and brilliant; often of a dull and tarniſhed colour, with efflorefcences of cobalt. The *gooſe dung ore* belongs to this ſpecies.

6. Grey ſilver ore, which differs no otherwiſe from the copper ore, called *fahlertz*, than in containing a larger proportion of this precious metal; it is well cryſtallized in triangular maſſes, whoſe edges are cut ſlopewiſe. The largeſt of theſe cryſtals have ſcarcely any brilliancy; the ſmalleſt diſperſed on a flat gangue, form a very agreeable appearance when expoſed to the light, on account of their great brilliancy. The grey ſilver ore affords from two to five marks of ſilver per quintal. This ore is ſometimes found in organic matters, whoſe form it perfectly imitates; it is then called *figurate ore of ſilver;* ſuch is the ore which reſembles the blades of corn, and that which Romé de Liſle obſerved in the form of cones of the pine. Wood has likewiſe been found mineralized by this ſpecies of ore. The grey ſilver ore contains ſilver, copper, iron, arſenic, and ſulphur. When the iron is in ſmall proportion, it is called *white ſilver ore*. This laſt muſt not be confounded with galena, containing ſilver, which the workmen ſometimes call ſilver ore.

7. Black ſilver ore, called *nigrillo* by the Spaniards, is nothing more, according to Lehman and Romé de Liſle, than a decompoſition of the red or grey ſilver ore, or a ſort of middle ſtate between theſe ores and native ſilver; it is often met with. The latter mineralogiſt obſerves, that the ſolid, ſpongy, or porous ſpecimens, are produced by the earth and vitreous ore, and are much richer than thoſe ſpecimens which are friable, and of a pitchy colour, whoſe origin is owing to the alteration of white or grey ſilver ores. From theſe cauſes, it is very ſubject to vary in the quantity of its product; in general it affords from ſix or ſeven pounds to near ſixty pounds per quintal.

8. *Corneous ſilver ore*, or the natural combination of ſilver

with the muriatic, and a ſmall quantity of ſulphuric acid, is of a dirty yellowiſh grey, ſometimes it is of a fawn colour; it is rarely tranſparent, eaſily yields to the knife, and melts by the flame of a candle. It is found cryſtallized in cubes, but moſt commonly in irregular maſſes. Portions of native ſilver are frequently found inſerted in its maſs. It was formerly thought to contain ſulphur and arſenic, but mineralogiſts at preſent are agreed reſpecting its nature. Cronſtedt, Lehman and Sage, Woulf, Lommer and Bergman, diſtinguiſhed the preſence of the muriatic acid, which is diſengaged by heat. Woulf likewiſe diſcovered that it contains the ſulphuric acid. It is found in Saxony, at St. Marie, at Guadalcanal in Spain, and at Allemont in Dauphiny.

9. The *ſoft ſilver ore* of Wallerius is native or mineralized ſilver, interſperſed in greater or leſs quantities, in coloured earths. Many varieties of colour are obſervable in earths containing ſilver, from the dirty grey to the deep brown.

10. Laſtly, Silver is found often combined with other metallic matters in the ores we have deſcribed, ſuch as miſpickel, the grey cobalt ore, kupfer-nickel, or ore of nickel, ſulphure of antimony, which often preſents the variety called *plumoſe ſilver ore*, blend, galena, martial pyrites, and white copper ores: theſe laſt are of the ſpecies of grey ſilver ores. All theſe ſubſtances frequently contain a ſufficient quantity of ſilver to be worked with profit; but it is eaſy to conceive that they ought not to be deſcribed like the foregoing, as proper ores of ſilver, and that it is ſufficient to remark that they are partly compoſed of this metal.

The aſſay of ſilver ores varies according to their nature; ſuch as contain native ſilver ore, require, in ſtrictneſs, nothing more than ſeparating and waſhing. Trituration with running mercury may be uſed for the accurate ſeparating of this metal from the marine ſubſtances, which change it; the fluid metal diſſolves the ſilver, and may be afterwards driven off by fire. Sulphureous ſilver ores require to be roaſted, and afterwards melted with a greater or leſs quantity of flux; in this fuſion, ſilver is obtained commonly alloyed with lead, copper, iron, &c. For the ſeparation and accurate aſcertaining of the quantity of precious metal contained in this alloy, a proceſs entirely chemical is uſed, which depends on the properties of the imperfect metals. Lead being capable of vitrifying, and of carrying with it in its vitrification the imperfect metals, ſuch as iron and copper, without acting on ſilver, this property is uſed to ſeparate the perfect metal from thoſe with which it is alloyed; the ſilver is melted with a quantity of lead, which muſt be ſo much the more conſiderable in proportion as the quantity of baſe metal is ſuppoſed to be greater. This alloy is then put in flat and porous veſſels, made of calcined bones and water; this kind of crucible, which is called a *cuppel*, is well adapted to abſorb the glaſs of lead, which is formed in the operation of cuppellation. After this proceſs the ſilver remains pure. In order to determine what quantity of imperfect metal it contains, or its degree of fineneſs, the maſs of ſilver is ſuppoſed to be divided into twelve parts, called *pennyweights*, and each of theſe pennyweights into twenty-four grains; if the maſs of ſilver has loſt a twelfth of its weight, it is called ſilver of eleven pennyweights fine; if it has loſt only a twenty-fourth, it is called ſilver of eleven pennyweights twelve grains fine, and ſo forth. The cuppel, after this operation, is found to be much heavier, and contains the oxyd of vitreous lead, and that of the imperfect metals, which were united with the ſilver, and have been ſeparated by the lead. As the lead itſelf almoſt always contains a ſmall quantity of ſilver, it is neceſſary firſt to cuppel it by itſelf, in order to determine the quantity of the ſilver it contains, and a deduction muſt be made from the button of fine ſilver obtained of the ſmall portion known to be contained in the lead made uſe of, which is called the *witneſs*. Cuppellation is attended with a phenomenon by which the artiſt is advertiſed of the ſtate of the proceſs as it goes forward. In proportion as the ſilver becomes pure by the vitrification and ſeparation of the lead, it appears much more brilliant than the portion which is not yet fine; the brilliant part increaſes by degrees, and when all the ſurface of the metal becomes pure and luminous, the inſtant in which it paſſes to this ſtate exhibits a flaſh or fulguration, which denotes that the operation is finiſhed. Cupelled ſilver is very pure with reſpect to the imperfect metals it may have contained, but it may contain gold; and as it always contains a certain quantity, another operation muſt be made to ſeparate theſe two perfect metals. As gold is much leſs changeable than ſilver by moſt ſolvents, the ſilver is diſſolved by the addition of the nitric or muriatic acids, or by ſulphur; and the gold, on which theſe ſolvents have little or no action, remains pure. This method of ſeparating ſilver from gold is called *parting;* we ſhall ſpeak of the different kinds of parting, after having deſcribed the action of each of the ſolvents on ſilver, when we ſhall ſpeak of the alloy of this metal with gold.

The large works where ſilver is extracted from its ores and purified are ſimilar to thoſe we have deſcribed for the aſſay of the ores of this metal. There are in general three methods of treating ſilver in the large way; the firſt conſiſts in triturating virgin ſilver with mercury; this amalgam is waſhed to ſeparate all the earth; it is then paſſed through the pores of bags of leather, and diſtilled in iron retorts; after which the ſilver is melted and caſt into ingots. This proceſs cannot be uſed with ſilver ores that contain ſulphur: theſe are roaſted and mixed with lead, to refine the precious metal by cuppellation. Rich ſilver ores are treated in this manner, but the poorer ores are treated in a different manner from the two foregoing; they are melted without previous roaſting, with a ſmall quantity of pyrites. This fuſion, which is called the *crude fuſion,* affords a mat of copper in combination with ſilver, which is treated with lead in the way of eliquation; the latter, which carries down the ſilver during the fuſion, is afterwards ſcorified on the cupel, and the perfect metal remains pure. Cuppellation in the large way differs from that which is made in the ſmall way, in this circumſtance, that in the firſt, the ſcorified lead is driven off by the action of a bellows, whereas, in the latter, the oxyd of vitreous lead is abſorbed by the cuppel.

The ſilver obtained by the proceſſes here deſcribed is, in general, much leſs liable to alteration than all the metals hitherto deſcribed. The contact of light does not at all change this metal, however long it be expoſed to it; heat melts it, cauſes it to boil, and to become volatilized, but without alteration. It does not melt in leſs than a white heat, but is more fuſible than copper. When it has been held in fuſion for a certain time it boils and emits vapours, which conſiſt of ſilver volatilized. This fact is proved by the exiſtence of the metal in the funnels of chimneys, under which large quantities are continually melted. It is likewiſe confirmed by the capital experiment of the Academicians of Paris, who expoſed very pure ſilver to the focus of Trudaine's lens. Theſe philoſophers obſerved, that the melted metal emitted a thick fume, which completely ſilvered a piece of gold held over it.

Silver, when ſlowly cooled, is capable of aſſuming a regular form, and cryſtallizes in quadrangular pyramids. Baumé has obſerved that this metal, in cooling, aſſumes a ſymmetrical form, which is obſervable on its ſurface by ſmall fibres, reſembling the feather of a pen. I have obſerved that the fine button obtained by cuppellation often preſents on its ſurface ſmall ſpaces of five or ſix ſides arranged among each other like a pavement; but the cryſtallization in tetrahedral pyramids, has not been well obſerved, except by Tillet, and the Abbé Mongez.

It has been long thought, and ſome chemiſts ſtill are of opinion, that ſilver is indeſtructible by the combined action of heat and air. It is certain that this metal, kept in fuſion with contact of air, does not appear to be ſenſibly altered; yet Junker had affirmed, that by treating it a long time in the reverberatory furnace, in the manner of Iſaacus Hollandus, ſilver was changed into a vitreous oxyd. This experiment has been confirmed by Macquer. That learned chemiſt expoſed ſilver twenty ſucceſſive times in a porcelain crucible to the fire of the furnace at Sèves, and at the twentieth fuſion he obtained a vitriform matter of an olive green, which appeared to be a true vitreous oxyd of ſilver. This metal, when heated in the focus of the burning glaſs, has always exhibited a white pulverulent matter on its ſurface, and a greeniſh vitreous covering on the ſupport it reſted upon. Theſe two facts remove all doubt reſpecting the alteration of ſilver; though it is much more difficult to oxydate than other metallic matters, yet it is capable of being converted, after a length of time, into a white oxyd, which, treated in a violent fire, affords an olive-coloured glaſs. It may perhaps be poſſible to obtain an oxyd of ſilver, by heating this metal, when reduced, into very fine laminæ, or in leaves, for a very long time in a matraſs, as is done with mercury. The electric ſpark ſeems alſo to oxydate this metal. At all events, it is certain, that ſilver does not combine with the baſe of vital air without great difficulty, and that heat does not favour this combination in the ſame manner as it does with almoſt all the other metals; but, on the contrary, diſengages that principle from it very readily: for the oxyds of ſilver are all eaſily reduced without addition, a circumſtance which depends on the ſlight adherence of the oxygen, which by heat and light is diſengaged in the form of vital air.

Silver is not changed by the action of air, its ſurface being ſcarcely tarniſhed by a very long expoſure to that fluid. Water does not act on it. Earths do not combine with it; but it is probable that its oxyd would give an olive green colour to glaſſes with which it might be fuſed.

The ſalino-terreſtrial matters and the alkalis do not ſenſibly act on ſilver. Sulphuric acid diſſolves it when very concentrated or boiling, and the metal is greatly divided. Much ſulphureous acid gas is diſengaged during this ſolution; the ſilver is converted into a white matter, on which ſulphuric acid muſt be poured, in order to hold it in ſolution: very ſmall needles of ſulphat of ſilver are obtained by evaporating this liquor. I have ſeveral times obtained this ſalt in plates, formed by the union of theſe needles length-wiſe. This ſalt melts in the fire, and is very fixed [c]; it is decompoſable by alkalis, copper, zink, mercury, &c. All the precipitates obtained by alkalis, are reducible without addition, and become converted into fine ſilver, in cloſed veſſels [d].

The nitric acid oxydates and diſſolves ſilver with rapidity, even without the aſſiſtance of heat. This ſolution is ſometimes performed ſo quickly, that in order to prevent the inconvenience that might ariſe, it is neceſſary to uſe ſilver in a lump. A large quantity of nitrous gas is diſengaged, and a white precipitate, more or leſs abundant, is formed, if the acid of nitre contains a portion of ſulphuric or muriatic acid. The nitric acid uſually becomes of a blue or green colour, but loſes this colour and becomes tranſparent as ſoon as the ſolution is finiſhed, if the ſilver made uſe of be pure; but on the contrary a greeniſh tinge remains when the ſilver contains copper. The pureſt ſilver which can be employed, ſometimes contains gold: in this caſe, as the nitric acid has ſcarcely any action on this perfect metal, the gold is ſeparated in the form of blackiſh flocks, in proportion as the ſilver is diſſolved. From the difference of the action of this acid on theſe two metals, it is ſuccefsfully employed in ſeparating them from each other, in the operation of parting by aquafortis. The nitric acid diſſolves more than half its weight of ſilver: this ſolution is exceedingly cauſtic, tinges the epidermis of a black colour, and entirely corrodes it. When highly charged with the metal, it depoſits ſlender brilliant cryſtals, reſembling theſe of boracic acid; when half evaporated, it affords, by cooling, flat cryſtals, which are either hexagonal, or triangular, or ſquare, and appear to be formed of a great number of ſmall needles, placed one beſide the other. Theſe plates are placed obliquely on each other; they are tranſparent, and very cauſtic, and are called the nitrat of ſilver, or *lunar cryſtals*. This ſalt is quickly altered by the contact of light, and blackened by combuſtible vapours. It detonates on heated charcoal, and leaves a white powder, which is pure ſilver. It is very fuſible: if it be expoſed to heat in a crucible, it firſt ſwells up and loſes the water of cryſtallization, after which it remains in fuſion; and if ſuffered to cool in this ſtate, it appears to be a grey maſs, and forms a preparation known in pharmacy and ſurgery by the name of *lapis infernalis*. It is not neceſſary in making this preparation to uſe the cryſtallized nitrat of ſilver, which is difficult and expenſive to obtain; as it is ſufficient to evaporate a ſolution of ſilver in the nitric acid to dryneſs, and to put this reſidue in a crucible or ſilver ladle, as Baumé adviſes, and to heat it ſlowly till it is in an undiſturbed fuſion, in which ſtate it muſt be poured into a mould, to give it the form of ſmall cylinders. If the cylinders of *lapis infernalis* be broken, they are found to be of a needle-formed texture, radiating from the axis of each cylinder. Nitrat of ſilver muſt not be too long heated to make the *lapis infernalis*, as by that means a part of the ſalt would be decompoſed, and a button of ſilver would be found at the bottom of the crucible. To aſcertain what paſſes in this operation, I have diſtilled this ſalt in the pneumato-chemical apparatus; they afforded nitrous gas, and vital air, mixed with a ſmall quantity of azotic gas; the ſilver was recovered in the matraſs, entirely reduced. The glaſs was opake like enamel, and of a beautiful marron brown colour. The brown colour of the glaſs in this experiment doubtleſs ariſes from oxyd of mangane ſe, or ſome other ſubſtance contained in it; for the colour of glaſs formed by the oxyd of ſilver is of an olive green, as we have already obſerved.

Nitrat of ſilver, expoſed to the air, does not attract moiſture; it is very ſoluble in water, and may be cryſtallized by the ſlow evaporation of that fluid.

The nitric ſolution of ſilver is decompoſed by the ſalino-terreſtrial ſubſtances and by alkalis, but with very different phenomena, according to the ſtate of theſe ſubſtances. Lime water forms a very abundant olive coloured precipitate; fixed alkaline carbonats precipitate it of a white colour; cauſtic ammoniac of a green, inclining to olive: the latter precipitation takes place after a conſiderable time.

Though the nitric acid acts with more energy than any other on ſilver, it has not the ſtrongeſt adheſion and affinity with the oxyd of that metal. The ſulphuric and muriatic acids are capable of depriving it of the oxyd of ſilver which it may hold in ſolution. Hence it is, that a few drops of theſe acids, poured into a nitric ſolution of ſilver, produce a precipitate of a white powder when the ſulphuric acid is uſed, or a thick *coagulum* when the muriatic acid is uſed. In the firſt caſe ſulphat of ſilver is formed; in the ſecond muriat of ſilver. Theſe two ſalts not being very ſoluble, are precipitated. It is not neceſſary to uſe the ſulphuric and muriatic acids in a diſengaged ſtate to produce theſe decompoſitions; the neutral ſalts reſulting from their union with alkalis and earthy matters, may be employed with equal advantage. A double decompoſition or combination then takes place, becauſe the nitric acid being ſeparated from the ſilver, unites with the baſe of the ſulphuric and muriatic ſalts. This difference of affinity between the acids and ſilver is the baſis of a proceſs uſed for procuring the nitric acid in a ſtate of purity, without any mixture of other acids; ſuch in a word as is neceſſary for many operations in metallurgy, and for the moſt part of chemical reſearches. As it ſeldom happens in the diſtillation of ſpirit of nitre, that this fluid is not mixed with a certain quantity of ſulphuric or muriatic acid, chemiſts have endeavoured to diſcover methods of ſeparating theſe ſeveral fluids, and they avail themſelves with ſucceſs of the nitric ſolution of ſilver for this purpoſe. This ſolution is poured into the impure nitric acid, till no more precipitate is formed. The depoſition formed by the ſulphat or muriat of ſilver, is ſuffered to ſubſide; the acid is decanted and diſtilled by a gentle heat, to ſeparate it from the ſmall portion of *lunar ſalt* it may contain; and the product is very pure nitric acid, called by artiſts *precipitated aqua-fortis.*

Moſt metallic matters are capable of decompoſing the nitric ſolution of ſilver, becauſe they have a ſtronger affinity than that metal with oxygen. The arſeniat of potaſh, diſſolved in water, produces a reddiſh precipitate in the nitric ſolution, which conſiſts of ſilver united with arſenic acid; this precipitate reſembles the red ore of ſilver. Silver may be precipitated in its metallic ſtate by moſt metals; but we ſhall more particularly attend to the ſeparation of this perfect metal by mercury or by copper, becauſe of the phenomena the firſt preſents, and the utility of the latter.

Silver ſeparated from the nitric acid by mercury is in its metallic ſtate, and the ſlowneſs of its precipitation produces a peculiar ſymetrical arrangement known by the name of *Arbor Dianæ*, or the *philoſophical tree.* There are many proceſſes for obtaining this cryſtallization. Lemery directs one ounce of fine ſilver to be diſſolved in nitric acid of moderate ſtrength: this ſolution is to be diluted with about twenty ounces of diſtilled water, and two ounces of mercury are to be added: in forty days a very beautiful vegetation is formed. Homberg has preſcribed a much ſhorter proceſs: according to this chemiſt, an amalgam of four drachms of leaf ſilver, with two drachms of mercury, muſt be made in the cold. This amalgam is to be diſſolved in a ſufficient quantity of nitric acid, and a pound and a half of diſtilled water muſt be added to the ſolution. A little ball of the ſoft amalgam of ſilver muſt be put into an ounce of this liquid, and the precipitation takes place almoſt inſtantly. The precipitated ſilver, united to a portion of the mercury, diſpoſes itſelf in fibres of a priſmatic appearance on the ſurface of the amalgam: other fibres appear and inſert themſelves in the foregoing, ſo as to exhibit a vegetation in the form of a buſh. Laſtly, Baumé has deſcribed a method of obtaining the Arbor Dianæ, which differs in ſome reſpects from that of Homberg, and ſucceeds with greater certainty; he directs ſix drachms of the ſolution of ſilver, and four of the ſolution of mercury, in the nitric acid, both well ſaturated, to be mixed, and five ounces of diſtilled water to be added to this liquor. The mixture muſt be poured into an earthen veſſel, upon ſix drachms of an amalgam of ſilver, made with ſeven parts of mercury and one part of ſilver. Theſe two methods ſucceed much more quickly than that of Lemery, by the reciprocal action and affinity between the metallic ſubſtances. In fact, the mercury contained in the ſolution attracts that of the amalgam; the ſilver contained in the latter acts likewiſe on that which is held in ſolution, and from theſe attractions a quicker precipitation of the ſilver takes place. The mercury, which compoſes a part of the amalgam, being more abundant than is neceſſary to precipitate the ſilver from the ſolution, produces likewiſe a third effect of conſiderable importance; it attracts the ſilver by the affinity and tendency it has to combine with that metal, and it effectually combines with it; ſince the vegetations of the Arbor Dianæ are a true brittle amalgam of a cryſtallized form. This cryſtallization ſucceeds much better in conical veſſels, or glaſſes, than in round or open veſſels, ſuch as the cucurbit recommended by Baumé. It may likewiſe be obſerved, that it is neceſſary to place the veſſel in which the experiment is made, in a ſituation where it may not be ſhaken, or agitated, as ſuch circumſtances would effectually prevent the ſymetrical arrangement of the amalgam.

Copper plunged in the ſolution of ſilver, precipitates this metal likewiſe in a brilliant and metallic form. This proceſs is uſually employed to ſeparate the ſilver from its ſolvent, after the proceſs of parting. Plates of copper are immerſed in the ſolution, or the ſolution itſelf is poured into a veſſel of copper; the ſilver immediately becomes ſeparated in whitiſh grey flocks. When the liquor becomes blue, and is deprived of all its ſilver, it is decanted off; the ſilver, after being waſhed ſeveral times in water, is melted in a crucible and cupelled, in order to ſeparate it from the portion of copper with which it united during the ſeparation. The ſilver afforded by this operation is the pureſt of all; it is twelve penny-weights fine. From theſe two precipitations of ſilver by mercury and copper, we ſee, that metals ſeparated from their ſolvents by other metallic matters, are precipitated with all their properties. This phenomenon depends, as we have obſerved in the hiſtory of copper, on the circumſtance that the metals, immerſed in the ſolution of ſilver, take the oxygen from the latter, by virtue of their ſtronger affinity.

The muriatic acid does not immediately diſſolve ſilver, but it perfectly diſſolves its oxyd. When this acid is ſurcharged with the oxygen, it readily oxydates the metal. This no doubt accounts for what happens in the proceſs of *dry parting*. The operation conſiſts in expoſing plates of gold alloyed with ſilver to a heat in a cement, compoſed of a mixture of ſulphat of iron and muriat of ſoda: the ſulphuric acid diſengages the muriatic acid, gives it a portion of its oxygen, and the latter acts on, and diſſolves the ſilver.

A much ſhorter and eaſier proceſs is uſed to combine the muriatic acid with the oxyd of ſilver, by pouring it into a nitric ſolution of the metal. The very abundant precipitate, which is inſtantly formed, is a combination of the muriatic acid with ſilver, which has a ſtronger affinity with this acid than with that of nitre, and conſequently quits the latter to unite with the former. The ſame combination is obtained by pouring the muriatic acid into a ſolution of ſulphat of ſilver, becauſe this has a ſtronger affinity than the ſulphuric acid with the metal. The muriatic acid may likewiſe be combined with ſilver, by heating it on an oxyd of the metal precipitated from the nitric acid by fixed alkali.

The muriat of ſilver poſſeſſes many properties which deſerve to be known; it is ſo fuſible, that it melts when expoſed in an apothecary's phial to a mild heat; as for example, that of hot aſhes. By this fuſion it is converted into a grey and ſemitranſparent ſubſtance, reſembling horn, and for that reaſon has been called *luna cornea*. If it be poured on a ſtone it becomes fixed in the form of a friable matter, cryſtallized as it were in fine ſilvery needles. When heated for a long time with contact of air, it is decompoſed; it paſſes eaſily through the crucibles; part is volatilized, and part is reduced into metal, affording globules of ſilver, interſperſed among the portion of the muriat of ſilver, which is not yet decompoſed. This ſalt, expoſed to light, loſes its white colour, and becomes brown in a ſhort time. It diſſolves in water in but a very ſmall quantity; a pound of diſtilled boiling water taking up only three or four grains, according to the experiment of Monnet. Alkalis are capable of decompoſing muriat of ſilver, diſſolved in water, or in the dry way by heat; this method affords the pureſt and fineſt ſilver known. A mixture of four parts of potaſh, or carbonat of potaſh, with one part of muriat of ſilver, is melted in a crucible: when it is in ſtrong fuſion it is taken from the fire, ſuffered to cool, and broken; the ſilver is found beneath the muriat of potaſh formed in the operation, and the ſuperabundant portion of alkali employed. Baumé, the inventor of this proceſs, affirms, that the quantity of alkali he directs, prevents the muriat of ſilver from paſſing through the crucible, by acting on all its parts, which it decompoſes at once. Margraaf, has given another proceſs for reducing this ſalt, and obtaining perfectly pure ſilver: five drachms fixteen grains of muriat of ſilver are triturated in a mortar, with one ounce and a half of ammoniacal carbonat, a ſufficient quantity of diſtilled water being added to form a paſte; this mixture is agitated till the ſwelling and effervеſcence, which are excited, have ſubſided. Three ounces of purified mercury are then added, and triturated, till a perfect amalgam of ſilver is obtained: this is waſhed with a large quantity of water, the trituration ſtill being continued, and the waſhing renewed, till the water paſſes off very clear, and the amalgam is very bright. The amalgam being then dried and diſtilled in a retort, till the veſſel has acquired a white heat, the mercury paſſes into the receiver, and the ſilver is found pure at the bottom of the retort. In this way the metal is obtained in the moſt perfect ſtate of purity, and without any ſenſible loſs. This is the ſilver which ought to be uſed in the nicer chemical experiments. The water employed in waſhing the mixture carries off two ſubſtances; a certain quantity of ammoniacal muriat, which it holds in ſolution, and a white inſoluble powder. When the latter is ſublimed, a ſmall quantity of ſilver is found at the bottom of the ſublimatory veſſel. This experiment ſhows, that muriat of ſilver is not completely decompoſed, unleſs by the double affinity. In fact, in the proceſs of Margraaf, the ammoniac does not unite with the muriatic acid, but becauſe the ſilver combines on its part with the mercury, which attracts and tends to ſeparate it from the acid, which the alkali alone could not do. It is eaſily ſeen, that this long and expenſive operation can only be uſed in the ſmall works of a chemical laboratory. If muriat of ſilver in large quantities be required to be reduced, either fixed alkalis, or ſome metallic ſubſtance, muſt be uſed, which have a ſtronger affinity than ſilver with the muriatic acid; ſuch, among others, are antimony, lead, tin, iron, &c. If one part of muriat of ſilver be melted in a crucible with three parts of one of theſe metals, the ſilver will be found reduced at the bottom of the crucible, and the metal united to the muriatic acid. Silver precipitated in this manner is very impure, and always contains a portion of the metal uſed for the reduction; and as lead is moſt commonly employed, according to the advice of Kunckel, the ſilver obtained requires to be cupelled; it cannot conſequently be brought to the ſame ſtate of purity with the ſilver reduced directly by alkalis, or by the proceſs of Margraaf.

The nitro-muriatic acts ſtrongly on ſilver, and precipitates it in proportion as it is diſſolved: this effect may eaſily be underſtood; the nitric acid firſt diſſolves the metal, and the muriatic acid ſeizes it, forming muriat of ſilver, which falls down on account of its ſmall degree of ſolubility. This proceſs may be uſed to ſeparate ſilver contained in gold [e].

The action of the other acids on ſilver are not well known; it is only known that a ſolution of borax produces a very abundant white precipitate from the nitric ſolution of this metal, and that this precipitate conſiſts of the boracic acid united to a portion of the oxyd of ſilver.

This metal does not appear to be altered by neutral ſalts; it is certain that it does not detonate with nitre, nor decompoſe ammoniacal muriat. This unchangeableneſs of ſilver with nitre affords a good method of ſeparating it by detonation from the imperfect metals with which it may be united, ſuch as copper, lead, &c. The alloyed metal muſt be melted with the addition of nitre; the ſalt detonates and burns the portion of foreign imperfect metal, and the ſilver remains at the bottom of the crucible, in a ſtate of much greater purity than before [f].

Almoſt all combuſtible matters have a certain action on ſilver; no metal is more quickly tarniſhed and coloured by inflammable matters; ſulphurated hydrogen gas, from whatever ſubſtance it may be diſengaged, communicates to it immediately upon contact, a blue or violet colour, inclining to black, and greatly diminiſhes its ductility. It is well known that fetid animal vapours, ſuch as thoſe of neceſſary houſes, putrified urine, and hot eggs, produce the ſame effect on this metal. The mutual action of theſe two bodies, and the kind of combination which ariſes from them, has not yet been examined into.

Sulphur combines readily with ſilver; this combination is uſually made by ſtratifying plates of the metal with flowers of ſulphur in the crucible, and quickly fuſing the mixture: a deep violet coloured maſs is produced, much more ſoluble than ſilver, brittle, and diſpoſed in needles; in a word, a true artificial ore. This combination is eaſily decompoſed by the action of fire, becauſe of the volatility of the ſulphur and the fixity of ſilver; the ſulphur is conſumed and diſſipated, and the ſilver remains pure; alkaline ſulphure diſſolves this metal in the dry way. When one part of ſilver is melted with three parts of ſulphure of potaſh, the metal diſappears, and becomes ſoluble in water, together with the ſulpure. If an acid be poured into this ſolution, a black ſulphurated precipitate of ſilver is obtained. Silver left in a ſolution of ſulphure of potaſh quickly aſſumes a black colour, and the ſulphur appears to quit the alkali to unite with, and mineralize the metal, as we have likewiſe obſerved it does with mercury.

Silver unites with arſenic, which renders it brittle; but the action of the arſenic acid on this perfect metal is not yet known.

It does not combine with cobalt without difficulty.

It unites perfectly eaſily with biſmuth, and forms a brittle mixed metal, whoſe ſpecific gravity is greater than that of the two metals ſeparately taken. According to Cronſtedt, ſilver does not unite with nickel; but when theſe metals are melted together, they remain beſide each other, as if their ſpecific gravity were preciſely the ſame.

It mixes by fuſion with antimony, and affords a very brittle alloy. It ſeems capable of decompoſing ſulphure of antimony, and of uniting with the ſulphur of that mineral, with which it has a ſtronger affinity than the antimony.

Silver combines readily with zink by fuſion; an alloy is produced by this combination, granulated at its ſurface, and very brittle.

It diſſolves completely, and even without heat, in mercury. To produce this ſolution, ſilver leaf may be triturated with the metallic fluid; an amalgam is immediately produced, whoſe conſiſtence varies according to the relative quantities of the two ſubſtances. This amalgam is capable of aſſuming a regular form; by fuſion and ſlow cooling, it affords tetrahedral priſmatic cryſtals, terminated by pyramids of the ſame form. The mercury aſſumes a degree of fixity in this combination; for a much ſtronger heat is neceſſary to ſeparate it from the ſilver, than would be required to volatilize it alone. Silver is capable of decompoſing corroſive mercurial muriat, either by the dry or the humid way.

It unites perfectly with tin, but loſes its ductility by the ſmalleſt addition of this metal.

It readily becomes alloyed with lead, which renders it very fuſible, and deprives it of its elaſticity and ſonorous quality.

It unites with iron, and forms an alloy, which has been but little examined into, but may probably become of the greateſt utility in the arts.

Laſtly, It melts and combines in all proportions with copper; the latter does not deprive it of its ductility, but renders it harder and more ſonorous, forming an alloy which is often employed in the arts[*].

Silver is a metal highly uſeful, on account of its ductility, and its indeſtructibility by fire and by air. Its brilliancy renders it capable of ſerving the purpoſes of ornament. It is applied on the ſurface of different bodies, and even on copper; and likewiſe enters into the texture of rich ſilks; but its moſt conſiderable uſe is that of affording a matter, proper by its hardneſs and ductility, to form veſſels of all ſorts. Silver plate is uſually alloyed with one twenty-fourth of copper, which gives it a greater degree of hardneſs and coherence, and does not render it at all noxious, becauſe the twenty-three parts of ſilver cover the copper, and entirely prevent its noxious effects.

Laſtly, Silver is employed as a medium of exchange, in the form of money; in this caſe it is alloyed with one twelfth part of copper, and is conſequently eleven penny-weights fine.

NOTES ON CHAPTER XX.

SILVER.

[a] The ſpecific weight of ſilver, according to Bergman, is 10,552.

[b] Silver melts, according to Wedgewood, at a heat equal to 4717 of Fahrenheit's ſcale.

[c] The acid is driven off by heat, and the ſilver left, even without addition, in its metallic ſtate.

[d] Sulphat of ſilver requires 8727 parts of boiling water to diſſolve it.

[e] Fluoric acid diſſolves the oxyd of ſilver, and forms with it a ſalt, which is decompoſed by the ſulphuric and muriatic acids.

A ſolution of borax is ſaid to produce no precipitation in a ſolution of ſilver in the nitric acid.

Phoſphoric acid diſſolves only a very ſmall quantity of the oxyd of ſilver.

Tartarit of ſilver has been formed, but its properties are little known.

Oxalic acid forms a ſalt, very difficultly ſoluble in water, with oxyd of ſilver. Oxalat of ſilver acquires a black colour by expoſing it to the rays of the ſun. Oxalic acid takes this oxyd from nitric and ſulphuric acids.

Benzoic acid diſſolves only a very ſmall portion of oxyd of ſilver. Its combination is moſt eaſily effected by mixing a ſolution of benzoat of potaſh with a ſolution of ſilver in the nitric acid. This ſalt diſſolves readily in hot, but difficultly in cold water. It receives a brown colour from light, is decompoſed in the fire, and the oxyd of ſilver is reduced.

Acetic acid diſſolves oxyd of ſilver by digeſtion. The ſolution affords, by evaporation, thin needle-ſhaped cryſtals, which are decompoſed in the fire.

Succinic acid diſſolves the oxyd of ſilver, and ſhoots with it into long thin parallel foliated cryſtals, which are difficultly ſoluble in water, and eaſily decompoſed in the fire.

Gallat of ſilver is at firſt of a reddiſh, but becomes afterwards of a brown colour.

Pruſſiat of potaſh diſſolves the oxyd of ſilver. This ſolution is not decompoſed by muriat of ſoda.

[f] The oxyd of ſilver precipitated by cauſtic alkali, from its ſolution in nitric acid, is ſoluble in ammoniac. Berthollet diſcovered that this combination poſſeſſes the property of fulminating in a degree ſuperior to that of oxyd of gold. He remarks, that this ſubſtance fulminates with violence while ſtill humid, if it be preſſed with a hard body. In this experiment the ſilver was found conſtantly reduced. In the dry ſtate, the ſlighteſt touch, or friction of any kind, is ſufficient to make it fulminate. If a ſmall retort be filled with a ſolution of the oxyd of ſilver in ammoniac, and expoſed to a boiling heat, bubbles of azotic gas are diſengaged, and ſmall cryſtals are formed, which are opake, and have a metallic appearance. Theſe cryſtals detonate by the ſlighteſt touch, even when covered by the liquor, and, in large quantities, produce dangerous exploſions. The detonation of the oxyd obtained by lime was much more powerful than that by the fixed alkalis. See *Ann. de Chem.* Tom. I. p. 52. For a farther account of the proportion of fulminating ſilver, ſee *Minutes of a Philoſophical Society*, p. 323.

[g] Mr. Keir has deſcribed, in the Philoſophical Tranſactions for 1790, a method of ſeparating theſe metals from each other, which appears to be particularly uſeful in the arts. It conſiſts in putting the mixture of ſilver and copper, or copper plated with ſilver, into an earthen glazed pan, and pouring on them a mixture of ſulphuric acid and nitrat of potaſh, in the proportion of from 8 to 10 parts of the acid to 1 part of the nitrat. The mixture is to be ſtirred ſo that the ſurface of the pieces of metal may be frequently expoſed to freſh portions of the liquor. The ſolution is to be aſſiſted by a gentle heat of from 100 to 200 of Fahrenheit's ſcale. When the liquor is nearly ſaturated, the ſilver is to be precipitated from it by the addition of muriat of ſoda. A muriat of ſilver is formed, eaſily reducible in a crucible by melting it with a ſufficient quantity of potaſh; and laſtly, by refining the melted ſilver, if neceſſary, with a little nitrat of potaſh thrown on it. In this manner the ſilver will be got ſufficiently pure, while the copper remains unchanged.

CHAPTER XXI.

CONCERNING GOLD.

GOLD, or Sol of the alchemiſts, is the moſt perfect and the leaſt changeable metal known; it is of a yellow brilliant colour; no other ſubſtance in nature is ſo heavy, platina excepted, for it loſes only between one nineteenth and one twentieth of its weight in water. Neither its hardneſs nor its elaſticity are very conſiderable. Its aſtoniſhing ductility, which are well aſcertained by the ſmallneſs of gold wire, and the thinneſs of gold leaf, is ſuch, than an ounce of this metal is ſufficient to gild a ſilver wire of 444 leagues in length, and it is reduced into plates ſufficiently thin to be blown away by the wind. A grain of gold, according to the calculation of Lewis, is capable of covering the ſurface of more than 1400 ſquare inches. It is the moſt tenacious of all the metals. A gold wire of one tenth of an inch in diameter, being capable of ſuſtaining a weight of 500 pounds without breaking. Gold ſoon becomes hard under the hammer, but immediately recovers it's ductility by ignition.

The colour of gold is ſuſceptible of conſiderable variety; it is more or leſs yellow, and ſome ſpecimens are almoſt white; theſe differences however ſeem to depend on ſome alloy. Gold has neither ſmell nor taſte; it is capable of cryſtallizing by cooling, in ſhort quadrangular pyramids, as Tillet and Mongez have obſerved.

Gold is almoſt always found in a native or virgin ſtate: it is ſometimes met with in ſmall inſulated maſſes, diſpoſed on a matrix of quartz; ſometimes it is in ſmall ſpangles, intermixed with ſand at the bottom of waters; and laſtly, it is obtained from many ores into the compoſition of which it enters, ſuch as galena, blend, red ſilver ore, and virgin ſilver. It is almoſt always united with a certain quantity of ſilver and other metals, forming natural alloys.

There are many varieties of native gold, in plates, in grains, in octahedral cryſtals, in four ſided priſms, ſtriated in filaments, and in irregular maſſes. Sage thinks, that native gold in priſms is united to a certain quantity of mercury, which renders it brittle.

Modern mineralogiſts admit ſeveral ſpecies of gold ores.

1. Native gold united to ſilver, copper, iron, &c. found in Peru, Mexico, Hungary, Tranſylvania, &c.

2. The auriferous pyrites: it is not eaſily diſtinguiſhed by the eye from other pyrites; the gold is ſeparated by treating the ore with the nitric acid, and waſhing the reſidue. The gold ſeems to be merely mixed with martial pyrites. Certain arſenical pyrites, and in particular thoſe of Salſberg, in Tyrol, likewiſe contain a ſmall portion of gold.

3. Gold mixed with ſilver, lead, or iron, mineralized by ſulphur. This auriferous ore is of a very compounded nature; according to Sage it conſiſts of blend, galena, ſpecular antimony, copper, ſilver, and iron; the gold melts and iſſues out with the lead when the maſs is expoſed to heat; it comes from Nagaya in Tranſylvania.

The method of aſſaying ores of gold differs according to the nature of the mineral; pulverizing and waſhing are ſufficient for the ſeparating of native gold from its matrix; if the gold be alloyed with other metals, it will be neceſſary to roaſt the ore, and the metal, after being extracted by fuſion, muſt be cupelled with lead, and parted with aqua-fortis.

The method of extracting gold from its ores may be eaſily underſtood, from the conſideration of the metallurgic proceſſes we have already deſcribed. Native gold requires only to be ſeparated from its gangue; for this purpoſe it is ground, and afterwards waſhed; it is then triturated in a mortar, filled with water, together with ten or twelve parts of mercury: the water which waſhes the metallic ſubſtance, and ſeparates thoſe parts which are merely earthy, muſt be decanted off. When the amalgam formed in this operation is thus deprived of all its earth, and appears very pure, it is preſſed in bags of ſhamoy leather; a great part of the mercury paſſes through the pores of the ſkin, and the gold remains united with a certain portion of the ſemi-metal. The remaining mercury is ſeparated by diſtillation from the amalgam, and the pure gold being fuſed, is caſt into bars or ingots. The gold which is found combined in the ores of other metals, ſuch as thoſe of lead, copper, and ſilver, is extracted by eliquation, cupellation, and parting. The lead which flows during the eliquation of the copper carries the ſilver and the gold with it. Cupellation afterwards ſeparates the lead, and the proceſs of parting ſeparates the ſilver, as we ſhall hereafter obſerve.

Gold expoſed to the fire becomes red long before it melts. In a ſtrong heat it appears of a brilliant ſea green colour; but it does not melt till heated to whiteneſs, and cryſtallizes by ſlow cooling. The ſtrongeſt heat of a furnace continued for an indefinite time does not produce any change in this metal: Kunckel and Boyle made this experiment, by expoſing gold for ſeveral months to the fire of a glaſs houſe. This inalterability, however, is merely relative to the fires we are able to make with combuſtible ſubſtances; for it appears certain that a ſtronger heat, ſuch as that of the ſun concentrated by glaſs lenſes, is capable of depriving it of its metallic properties. Homberg obſerved that this metal, when expoſed to the focus of the lens of Tſchirnhauſen, fumed, was volatilized, and even vitrified. Macquer found, that gold expoſed to the focus of the lens of Trudaine, melted and exhaled a fume which gilded ſilver, and was therefore gold in a volatile ſtate; that the globule of melted gold was agitated with a rapid circular motion, and became covered with a dull, and, as it were, earthy pellicle; and, laſtly, that a violet vitrification was formed on the middle of the globule. This vitrification gradually extended, and produced a kind of button, flatter, or of a larger curvature, than that of the globule of gold, which ſtuck on the globule itſelf, as the tranſparent cornea appears on the ſclerotica of the eye. This glaſs increaſed in ſize, while the gold itſelf continually diminiſhed; the ſupport always appeared tinged with a purple colour, apparently produced by the abſorption of part of the glaſs.

Time did not permit Macquer to vitrify entirely a certain quantity of gold. This celebrated chemiſt obſerves, that it is a neceſſary condition, that the violet glaſs ſhould be reduced with combuſtible matters, in order to juſtify the aſſertion, that it is the oxyd of that perfect metal, which would evidently appear to be the caſe, if it became revived into gold. However this may be, we think it may be conſidered as a true vitrified oxyd of gold, with ſo much the greater probability, as in many operations with this metal, preſently to be deſcribed, the purple colour is conſtantly produced, and that many preparations of gold are employed to give that colour to enamel and porcelain. Gold is therefore oxydifiable like the other metals, and only requires, as likewiſe does ſilver, a ſtronger heat, and a longer time to unite with the baſe of air than other metallic ſubſtances. Theſe circumſtances, no doubt, bear relation to its denſity, and its ſmall tendency to unite with oxygen. Gold may be converted into the ſtate of purple oxyd by the action of a ſtrong electric ſpark.

Gold is not changed by expoſure to air; its ſurface becomes tarniſhed merely by the depoſition of foreign bodies which continually float in the atmoſphere. Water does not at all change it, though, according to the experiments of Lagaraye, it ſeems capable of dividing it.

Gold does not combine with earths, or the ſalino-terreſtrial ſubſtances, in its metallic ſtate; its oxyd makes a part of the compoſition of glaſſes, to which it gives a violet or purple colour.

Gold is not at all altered by the moſt concentrated ſulphuric acid, even though heated.

The nitric acid appears capable of diſſolving a ſmall portion of this metal; ſeveral chemiſts think that this ſolution is produced rather mechanically than by a true combination. Brandt was one of the firſt chemiſts who affirmed that the nitric acid diſſolves gold, and his aſſertion has been confirmed by Scheffer and Bergman; but it muſt be obſerved, that experiments made by the whole claſs of chemiſts of the Academy of Paris, ſhow, that the nitric acid only takes up a ſmall portion of gold in peculiar circumſtances, not mentioned by thoſe chemiſts. See *Annales de Chemie*, Tom. V. Deyeux, member of the College of Pharmacy, has obſerved, that the nitric acid diſſolves gold only when it is ſmoking, and charged with nitrous gas; he thinks that the acid in this ſtate is not pure, and affirms that it is *loaded with gas*, and by that means converted into a kind of *aqua regia*. We have formerly explained the difference between the nitrous and nitric acids.

The muriatic acid alone, and in a ſtate of purity, does not ſenſibly act on gold. Scheele and Bergman have diſcovered, that this acid, when oxygenated, diſſolves gold abſolutely in the ſame manner as *aqua regia*, and forms with this metal the ſame ſalt which is uſually obtained with the mixed acid employed to diſſolve it. The ſolution appears to take place in conſequence of the exceſs of oxygen united to the muriatic acid; it is made without ſenſible efferveſcence, a circumſtance common to all metallic ſolutions in the oxygenated muriatic acid[a].

Aqua regia has been conſidered as the true ſolvent of gold; it does not however diſſolve it better than the oxygenated muriatic acid. Without repeating, in this place, what we have elſewhere ſaid reſpecting the nature, properties, and differences of this mixed acid, according to the quantity of the two acids combined together in its formation, we ſhall only attend to its action on gold. As ſoon as the nitro-muriatic acid comes in contact with the metal, it attacks it with an efferveſcence which is ſo much the ſtronger, as the acid is more concentrated, the temperature higher, and the gold more minutely divided. The operation may be haſtened by a gentle heat, or at leaſt its commencement may be forwarded; the bubbles ſucceed each other without intermiſſion till a portion of the metal is diſſolved, after which this appearance gradually ceaſes, and cannot be renewed but by agitation or heat; nitrous gas is diſengaged during this ſolution. The nitro-muriatic acid, when ſaturated with as much gold as it is capable of taking up, is of a yellow colour, more or leſs deep, conſiderably cauſtic, corrodes animal matters, and tinges them of a deep purple colour. By cautious evaporation it affords cryſtals of a beautiful gold colour, reſembling topazes, and appearing to conſiſt of truncated octahedrons, and ſometimes tetrahedral priſms. This cryſtallization is not eaſily effected. Monnet thinks that it ariſes from the neutral ſalt formed in the nitro-muriatic acid, and affirms that it is neceſſary, in order to obtain theſe cryſtals, that an *aqua regia*, made with nitric acid and ammoniacal muriat, or muriat of ſoda, ſhould be employed: the mixed acid then contains either nitrat of ſoda, or ammoniacal nitrat. According to this chemiſt, either of theſe neutral ſalts cauſes the cryſtallization of gold: nevertheleſs it appears, that a ſolution of gold in a nitro-muriatic acid, is capable of affording cryſtals; and Bergman conſiders this ſalt as a true muriat of gold: if the cryſtals be heated, they melt and aſſume a red colour. This ſalt ſtrongly attracts the moiſture of the air. When a ſolution of gold is diſtilled, a beautiful red liquor is obtained, which is found to conſiſt of the muriatic acid, charged with a ſmall portion of gold. The alchemiſts, whoſe labours with gold were very great, gave the name of the *red lion* to this liquor. Some cryſtals of gold, of a reddiſh yellow colour, are likewiſe ſublimed in this proceſs; but the greateſt part of the metal remains at the bottom of the retort, and requires only to be fuſed, in order to regain all its properties.

The ſolution of gold is decompoſed by a great number of intermediums. Lime and magneſia precipitate gold in the form of a yellowiſh powder; fixed alkalis exhibit the ſame phenomenon; but it muſt be obſerved, that the precipitate is afforded very ſlowly, and that the ſolution aſſumes a reddiſh colour, if more alkali be added than is neceſſary; becauſe the exceſs of this ſalt rediſſolves the precipitated gold. The precipitate of gold may be reduced by heat alone, in cloſed veſſels, this oxyd readily ſuffering the oxygen to become diſengaged in the form of vital air. It is nevertheleſs capable of being fuſed with vitreous matters, and communicating a purple colour to them; for the precipitate of gold, formed by the mixture of a ſolution of gold and the liquor of flints, is uſed in enamels and porcelain.

Gold precipitated by fixed alkalis has likewiſe a property very different from that of gold in its metallic ſtate; it is ſoluble in the pure ſulphuric, nitric, and muriatic acids; all theſe acids, heated on the yellowiſh precipitate of gold, readily diſſolve it, but do not become ſufficiently ſaturated to afford cryſtals. When the ſolutions are evaporated, the gold is readily precipitated, as likewiſe happens by mere reſt. Monnet has obſerved, concerning the ſolution of gold by nut-galls *, a fact which ought not to be overlooked, viz. that the reddiſh precipitate it affords is readily ſoluble in the nitric acid, to which it gives a beautiful blue colour.

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* As we have only ſpoken of the precipitation of iron by nut-galls, it will be proper in this place to give a ſhort account of the phenomena this aſtringent ſubſtance preſents with moſt other metallic ſolutions.

Ammoniac precipitates the ſolution of gold in much greater abundance. This precipitate, which is of a brown yellow, and ſometimes of an orange colour, has the property of detonating with a conſiderable noiſe when gently heated: it is called *fulminating gold.* The ammoniac is abſolutely neceſſary in the production of fulminating gold; this preparation may be formed either by precipitating a ſolution of gold in nitro-muriatic acid, made with ammoniacal muriat, by the addition of fixed alkali, or by precipitating with ammoniac a ſolution of gold, made in *aqua regia*, compoſed of pure nitric and muriatic acids. The fulminating gold always weighs one fourth more than the gold diſſolved in *aqua regia*. The terrible effects of fulminating gold render it neceſſary to act with great caution in the management of this ſubject: it muſt be carefully dried in the open air, without being brought near the fire, as a ſtrong heat is not neceſſary to produce the fulmination, and friction alone is ſufficient for this purpoſe: the veſſels which contain it ought not to be cloſed with glaſs ſtoppers, but with cork; the moſt dreadful accidents have ſhown, that glaſs ſtoppers, by the fric-

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Nut-gall precipitates the ſolution of cobalt of a light blue colour; that of zink of a cinerous green; of copper green, which becomes grey and reddiſh; of ſilver, firſt reddiſh ſtriæ, which ſoon takes the colour of burnt coffee; that of gold purple. Theſe facts have been obſerved and deſcribed by Monnet, who likewiſe found that theſe precipitates are ſoluble in acids, and that alkalis unite to the laſt mentioned ſolutions, without occaſioning any precipitate.

To theſe the academicians of Dijon have added the following facts: Solution of arſenic is not altered by nut-gall; that of biſmuth, affords a greeniſh precipitate; of nickel, a white precipitate; of antimony, a blackiſh grey; of lead, a ſlate coloured precipitate, whoſe ſurface is covered with a mixture of green and red pellicles; laſtly, that of tin becomes of a dirty grey by the mixture of nut-gall, and affords an abundant precipitate, of a mucilaginous appearance.

We ſhall recur again to ſeveral of theſe facts at the article Gallic Acid, in the vegetable kingdom. It may, however, be remarked in this place, that the experiments which Monnet and the academicians of Dijon have made with the decoction of nut-galls, and which will be afterwards mentioned in the vegetable kingdom, relate to the action of the pure gallic acid on metallic ſolutions, as this will enable us to explain the difference in the reſults of theſe experiments.—*Note of the Author.*

tion they produce in the necks of the veſſels, expoſe the operator to great danger, from the fulmination of ſuch particles of the gold as may remain between the ſtopper and the neck. A terrible accident happened in the laboratory of Baumé, which is related in his *Chemie Experimentale et Raiſonée.*

The opinions of chemiſts have been various reſpecting the cauſe of the detonation of fulminating gold. Baumé ſuppoſed that a *nitrous ſulphur*, to which he attributes the fulminating property, is formed in this experiment; but Bergman has ſhown that this experiment is not admiſſible, ſince he made fulminating gold without the nitric acid, by diſſolving a precipitate of gold in the ſulphuric acid, and precipitating it again by the ammoniac. Neither does the fulmination of gold depend on ammoniacal nitrat, ſince this ſalt would certainly be waſhed off by the addition of much water; and it is not found that fulminating gold loſes its property by ſuch treatment. An attentive examination of the fulmination of gold ſhows, that it takes fire in the inſtant that it explodes; if it be heated very gently, brilliant ſparkles, ſimilar to thoſe of electricity, are ſeen to eſcape before its exploſion. The diſcharge of an electric jar produces a detonation, but a ſimple electric ſpark does not. Laſtly, after the fulmination, the gold is found in its metallic ſtate. The fulmination of gold therefore appears to be produced by a combuſtible matter; and as ammoniacal gas is neceſſary for the production of this compound, it is at preſent acknowledged that the exploſion ariſes from the volatile alkali. This theory is founded on the following facts:

1. Berthollet obtained ammoniacal gas by gently heating fulminating gold in copper tubes, one extremity of which was plunged, by means of a ſyphon, beneath the mercury of a pneumato-chemical apparatus. After this experiment the gold was deprived of its fulminating property, and reduced to the ſtate of an oxyd.

2. By expoſing fulminating gold to a degree of heat not ſufficient to cauſe it to fulminate, Bergman deprived it of that property by gradually volatilizing the ammoniacal gas.

3. When a few grains of fulminating gold are detonated in copper tubes, whoſe extremity is plunged beneath the mercury of the pneumato-chemical apparatus, azotic gas and a few drops

of water are obtained, and the gold is reduced. Berthollet, the inventor of this experiment, thinks that the ammoniac is decompoſed; that its hydrogen, uniting with the oxygen of the oxyd of gold, reduces this oxyd by forming water, and that the azotic gas is ſet at liberty; the fulmination, therefore, depends on the combuſtion of the hydrogen, and the ſudden diſengagement of the azotic gas.

4. Concentrated ſulphuric acid, melted ſulphur, fat oils, or ether, deprive gold of its fulminating property, by ſeizing the ammoniac. A ſingular property of fulminating gold, which ſhows its action, is, that when it is exploded on a plate of metal, either lead, tin, or even ſilver, it makes a mark or perforation in it. Laſtly, it does not appear capable of taking fire in very ſtrong and well cloſed veſſels, ſince, according to Lewis, it produced no exploſion in an iron ball well cloſed and ſtrongly heated. This phenomenon appears to depend on its being neceſſary that a ſpace ſhould be left for the diſengagement of the azotic gas. Bergman, who was not well acquainted with the nature of the gas diſengaged during the fulmination of this precipitate, and who conſidered it as pure air, together with a ſmall portion of ammoniac, has given a ſimilar explanation of the experiments made by the Royal Society of London *. Berthollet has diſcovered that the oxyd of ſilver, precipitated from the nitric acid by lime, and digeſted with ammoniac, which ſeparates it when the oxyd has aſſumed a blackiſh colour, acquires the property of detonating, not only by a heat very little ſuperior to that of boiling water, but likewiſe by the mere friction of any ſubſtance in the ſlighteſt manner. This fulminating ſilver is much more remarkable than even that of gold, whoſe fulmination is owing to the ſame cauſe. The ammoniac, decanted from this oxyd, depoſits, by ſlow evaporation, ſmall brilliant and lamellated cryſtals, which have the fulminating property, even at the bottom of the water, by ſimple friction.

The ſolution of gold is precipitated by alkaline ſulphures,

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* See the valuable diſſertation of this chemiſt on the *Fulminating Calx of Gold*, Vol. II. of his Chemical Eſſays. London, 1784.

while the fixed alkali unites to the acid; the ſulphur which falls down combines with the oxyd of gold; but this combination is by no means ſtrong, for the ſulphur may be driven off, and the perfect metal left pure, by the application of heat. We muſt here obſerve, that gold, precipitated from its ſolution by any intermedium whatſoever, is perfectly pure, even more ſo than gold purified by the proceſs of parting; becauſe it is ſeparated from the ſilver it may contain in this laſt proceſs, which may fall down in the form of a muriat, and takes place even during the ſolution of gold, as we have before remarked.

Gold has not the ſtrongeſt affinity of any metal with nitro-muriatic acid; almoſt all other metallic ſubſtances, on the contrary, ſeparate it from its ſolvent: biſmuth, zink, and mercury, precipitate gold. A plate of tin, plunged in a ſolution of gold, ſeparates the perfect metal in the form of a deep violet powder, called purple precipitate of *Caſſius*. This precipitate, which is uſed in painting in enamel and on porcelain, is prepared by diluting a ſolution of tin in nitro-muriatic acid, with a large quantity of diſtilled water, and pouring in a few drops of the ſolution of gold; when the ſolutions are well ſaturated, a red or crimſon precipitate is immediately formed, which at the end of a few days becomes purple: this precipitate is light, and, as it were, mucilaginous; it is ſeparated from the liquor by filtration, waſhed, and afterwards dried. It conſiſts of the oxyds of tin and gold, and its preparation is one of the moſt ſingular operations in chemiſtry, with reſpect to the variety and uncertainty of the phenomena it exhibits; ſometimes the precipitate is of a beautiful red, ſometimes its colour is a deep violet; and, what is ſtill more aſtoniſhing, it frequently happens that the mixture of the two ſolutions cauſes no precipitate whatever. Macquer, who very carefully obſerved theſe varieties, finds that they depend almoſt always on the ſtate of the ſolution of tin made uſe of; if the ſolution has been made too rapidly, the metal is too much oxydated, and is contained in too ſmall a quantity for the acid of the ſolution of gold to act on it; for it is to the action of this laſt on the tin, that he attributes the formation of the purple precipitate of *Caſſius*. In order to ſucceed in this operation, according to him, the ſolution of tin muſt be made very ſlowly, and in ſuch a manner that it may contain the greateſt poſſible quantity of metal not too much oxydated: on theſe principles he lays down the following proceſſes for making purple precipitate. Pieces of tin are to be diſſolved in a mixed acid, made of two parts of nitric acid and one part of muriatic acid, diluted with an equal weight of diſtilled water; on the other hand, very pure gold muſt be diſſolved by heat in a mixed acid, compoſed of three parts of nitric acid and one part of muriatic acid; the ſolution of tin is to be diſtilled in 100 parts of diſtilled water, and divided into two portions; to the firſt of the two, an additional quantity of water is to be added, and each muſt be tried with a drop of the ſolution of gold; that which affords the moſt beautiful red colour muſt be noted, and the ſame management adopted with the others; after which the ſolution of gold muſt be poured in till it no longer occaſions any precipitate.

Lead, iron, copper and ſilver, have likewiſe the property of ſeparating gold from its ſolvent; lead and ſilver precipitate it of a deep and dirty purple; copper and iron ſeparate it with its metallic brilliancy; the nitric ſolution of ſilver, and that of ſulphat of iron, likewiſe occaſion a red or brown precipitate from any ſolution of gold[b].

The action of neutral ſalts on gold is not perceptible; it is only obſerved, that borax, fuſed with this metal, alters its colour, and renders it remarkably pale, whereas nitre or muriat of ſoda re-eſtabliſh the colour. The ſolution of borax, poured into the ſolution of gold, cauſes a precipitate of boracic acid, charged with particles of the metal[c].

Sulphur is incapable of uniting with gold, and is advantageouſly uſed to ſeparate metals, with which gold may be alloyed, more eſpecially ſilver: this alloy is melted in a crucible, and flowers of ſulphur, or ſulphur in powder, is thrown on its ſurface: the latter ſubſtance, melting and combining with the ſilver, floats above the gold in the form of a blackiſh ſcoria. It muſt be obſerved, that this operation, called *dry parting*, never ſeparates the two metals accurately from each other, and that it is not uſed, except when the maſs of ſilver does not contain a ſufficient quantity of gold to repay the expence of the operation of parting by aquafortis.

Alkaline ſulphure completely diſſolves gold. Stahl even thinks that this proceſs was uſed by Moſes, to render the calf of gold adored by the Iſraelites ſoluble in water: to form this combination, a mixture of equal parts of ſulphur and potaſh muſt be quickly fuſed with one-eighth part of the whole weight of leaf gold; this matter being poured out and levigated on a ſtone, forms, with hot diſtilled water, a yellowiſh green ſolution, containing an auriferous ſulphure of potaſh; the metal may be precipitated by means of acids, and ſeparated from the ſulphur, which falls down at the ſame time by heating it in an veſſel[d].

Gold combines with moſt metallic ſubſtances, and exhibits many important phenomena in its combinations.

It unites with arſenic, and forms a brittle pale compound; the laſt portions of arſenic are very difficultly ſeparated from this alloy by the action of heat; the gold ſeems to communicate fixity to it.

The alloy of cobalt with gold has not been examined.

It unites with biſmuth, which renders it white and brittle, as do likewiſe nickel and antimony; as theſe metals are very oxydifiable, and, for the moſt part, fuſible, they are eaſily ſeparated from gold by the combined action of fire and air.

Sulphure of antimony has been greatly extolled by the alchemiſts for the purification of gold; when this ſubſtance is melted with gold, alloyed with other metallic ſubſtances, as copper, iron, or ſilver, the ſulphur of the antimony unites to the alloy, and ſeparates them from the gold, which is found at the bottom of the veſſel; this gold is contaminated with antimony, and muſt be purified by a white heat; the antimony, by this treatment, is volatilized, but the laſt portions require a very ſtrong heat to drive them off. It is likewiſe obſerved, that this metal carries up certain portions of gold in its volatilization. This proceſs, ſo celebrated by the alchemiſts, has not, therefore, any advantage over that in which ſulphur is employed alone.

Gold readily unites with zink; the product is a mixed metal, more brittle and white in proportion as the quantity of metal is greater. This alloy, made with equal parts of each metal, is of a very fine grain, and takes ſo beautiful a poliſh, that it has been recommended by Hellot to make mirrors of teleſcopes, not being ſubject to tarniſh. When the zink is ſeparated from the gold by calcination, the oxyd which this metal affords is reddiſh, and carries up a ſmall quantity of gold with it, as Stahl has obſerved.

Gold has a ſtronger affinity with mercury than with other metallic ſubſtances, and is capable of decompoſing their amalgams; it unites with mercury in every proportion, and forms an amalgam which is more ſolid, and of a darker colour, in proportion as the quantity of gold is greater; this amalgam liquifies by heat, and cryſtallizes by cooling, as do moſt compounds of this nature; it is not well known what regular form it takes. Sage affirms, that the cryſtals reſemble plumoſe ſilver, and, by the magnifier, appear to be quadrangular priſms. He likewiſe aſſerts, that the mercury acquires fixity in this combination. This amalgam is employed in water-gilding.

Though gold is not capable of oxydation by the action of the fire of our furnaces with acceſs of air, it nevertheleſs becomes ſo when heated together with mercury: if mercury, with one forty-eighth of its weight of gold, be heated in a flat-bottomed matraſs, whoſe neck is drawn out into a capillary tube, in the ſame manner as is done in the preparation of the oxyd of mercury, called *precipitate per ſe*, the two metallic ſubſtances become oxydated at the ſame time, and are converted into a deep red powder. This compound oxyd, according to Baumé, is obtained in much leſs time than that of mercury alone. We here ſee a metal, which, though very difficult to oxydate alone, aſſiſts and facilitates the oxydation of another metallic matter, which is likewiſe very difficultly oxydated.

Gold is eaſily alloyed with tin and lead; theſe two metals deprive it of all its ductility; its alloy with iron is very hard, and may be uſed to form cutting inſtruments, much ſuperior to thoſe made with pure ſteel: this mixture is grey, and attracted by the magnet. Lewis propoſes gold as a very proper and firm ſolder for ſmall pieces of ſteel.

Gold combines with copper, which gives it a red colour, and greater firmneſs, at the ſame time that it renders it more fuſible: this alloy is mixed in different proportions for money, plate, and toys. Laſtly, Gold is alloyed with ſilver, which deprives it of its colour, and renders it very pale: this alloy is not, however, made without a certain degree of difficulty on account of the different ſpecific gravities of theſe two metals, as Homberg obſerves, who ſaw them ſeparate during their fuſion. The alloy of gold with ſilver forms the green gold of the jewellers and gold-beaters.

As gold is of the moſt extenſive uſe, and, by the convention of mankind, is become, together with ſilver, the price of all the other productions of nature and of art, it is of importance to aſcertain the degree of purity of this precious metal, in order to prevent the deceptions which covetouſneſs might produce, and to cauſe the value of all the maſſes or pieces of gold diſperſed in commerce to be the ſame, equal weights being ſuppoſed. Severe laws, founded in juſtice, have therefore been made, eſtabliſhing the quantity of alloy neceſſary to be uſed, in order to give the due degree of hardneſs and rigidity to gold intended to form utenſils, in which theſe properties are neceſſary. Chemiſtry affords methods of aſcertaining the quantity of imperfect metal mixed with gold: the operation by which this knowiedge is obtained is called the *aſſay of gold.* Twenty-four grains of the gold intended to be aſſayed is cupelled with forty-eight grains of ſilver and four drachms of pure lead; the latter, in its vitrification, carries along with it the imperfect metals, ſuch as copper, &c. and the gold remains combined with the ſilver after the cupellation is finiſhed. Theſe two metals are ſeparated by an operation called *parting;* the parting of gold and ſilver conſiſts in the ſeparating of the two metals by a ſolvent, which acts on ſilver without affecting gold: aquafortis is commonly uſed. Silver is added to the gold, becauſe experience has ſhown that it is neceſſary the gold ſhould be mixed with at leaſt double its weight of ſilver, in order that the nitric acid may perfectly diſſolve the latter metal. As three parts of ſilver are uſually added to one of gold, this proceſs is called *quartation*, the gold being one-fourth of the weight of the alloy.

The metallic button being hammered flat, and care being taken to heat it from time to time, leſt it ſhould become hard and break in pieces, and ſome part fly away and be loſt, it is then rolled up in a ſpiral form, and put into a ſmall matraſs, with five or ſix drachms of precipitated aquafortis at 32°, which has been previouſly diluted with half its weight of water: a gentle heat is applied till the effervеſcence has taken place; the ſilver is diſſolved, and the metallic coil aſſumes a brown colour. When the action of the acid has ceaſed, it is decanted off, and about half an ounce at 30° is to be poured on the metal, and boiled on it till the ſilver be completely diſſolved. This ſecond operation is called *the repetition.* The ſpiral piece of metal, which is now become very thin and porous, is waſhed with water, and put into a crucible, together with the water; the water is then decanted off, the crucible made red hot, and the gold is found pure with all its metallic properties: by the weight of the gold, the quantity of alloy it originally contained is known. To aſcertain with preciſion the quantity of imperfect metal which the gold may contain, a given maſs of gold is ſuppoſed to contain twenty-four parts, called *carats;* and, for great exactneſs, each carat is divided into thirty-two parts, called thirty ſeconds of a carat: if the gold after the aſſay has loſt one grain out of twenty-four, it is gold of twenty-three carats; if it has loſt one grain and a half, it is gold of twenty carats ſixteen thirty-ſeconds, and ſo forth. The weight uſed in the aſſay of gold is called the *aſſay weight*, and uſually conſiſts of twenty-four grains; it is divided into twenty-four carats, which are likewiſe ſubdivided into thirty-two parts: an aſſay weight, which weighs twelve grains, is likewiſe uſed, but divided into twenty-four carats, and the carat into thirty-two thirty ſeconds.

There are two important obſervations neceſſary to be made reſpecting the operation of parting.

1. Some chemiſts have thought that the nitric acid diſſolves a ſmall quantity of gold with the ſilver. Baumé has obſerved, (pag. 117 and 118 du Tom. III. de ſa Chemie), that the ſilver obtained in the operation of parting contains a notable quantity of gold. Out of two pounds of fine grain ſilver, uſed by this chemiſt, to make lapis infernalis, he affirms, that he has uſually ſeparated near half a drachm of gold in the form of a black powder; however, when the parting is made with an acid not too much concentrated, and the ſolution is not carried too far, the gold remains pure and untouched, and the ſilver

contains no portion of that metal. The gentlemen of the chemical claſs of the Academy were directed, by adminiſtration, to examine whether, in the proceſs of parting, the nitric acid diſſolves gold ; they made a great number of experiments, from which they concluded, "that in the operation of parting, according to the received rules and uſage, there can never be the ſmalleſt loſs on the gold, and that this operation may be conſidered as perfect." This deciſion, extracted from the report publiſhed by the Academy, is well calculated for the information of the public, and the eſtabliſhment of commercial confidence reſpecting this ſubject.

2. Many docimaſtic philoſophers, and amongſt others Schindler and Schlutter, have thought that the coil of gold, after parting, retained a ſmall quantity of ſilver ; to this portion they gave the name of *ſurcharge*, or *interhalt*. Hellot, Macquer and Tillet, who were commiſſioned to examine the operation of the aſſayers of money, have proved, that it does not contain ſilver ; yet Sage affirms in his work, entitled, *L'Art d'eſſayer l'or et l'argent, page* 64. that this gold always retains a ſmall proportion of ſilver, and that it may be exhibited by diſſolving the metal in twelve parts of nitro-muriatic acid, the cold ſolution depoſiting, at the end of a certain time, and often, even twelve hours after it has been made, a ſmall quantity of muriat of ſilver, in the form of a white powder.

Gold is applied to a great number of uſes ; its ſcarcity and price prevent its being made into utenſils or veſſels ; but as its brilliancy and colour are very agreeable, methods have been found of applying it to the ſurface of a great number of bodies, which it at the ſame time defends from the impreſſions of the air.

This art, in general called gilding, is performed in a variety of methods. Leaves of gold are often applied on wood by means of ſome glutinous ſubſtance. A powder of gold is prepared by triturating the clippings of gold leaf with honey, waſhing the paſte with water, and drying the particles of gold which precipitate. Shell gold is an oxyd of gold, mixed with a mucilaginous water, or ſolution of gum. The name of gold in rags is given to the following preparation : Rags are ſteeped in a ſolution of gold, and afterwards dried and burned for uſe ;

a wet cork is dipped in theſe aſhes, and rubbed on ſilver, upon which the minutely divided gold eaſily applies itſelf. We have already ſpoken of water-gilding; this is done by previouſly cleaning a piece of copper, intended to be gilt, with ſand and weak aqua-fortis, called *aqua ſecunda*, after which the piece is plunged in a diluted ſolution of mercury; the mercury which precipitates cauſes the amalgam of gold to adhere; which is ſpread on the piece, after having waſhed it with water to carry off the acid; when the amalgam is uniformly ſpread, the piece is heated on charcoal, to volatilize the mercury, and the work is finiſhed by covering it with gilder's wax, compoſed of *red bole*, *verdigriſe*, *alum*, or *martial vitriol*, incorporated with yellow wax, and heated once more to burn off the wax.

The other uſes of gold, for toys, laces, &c. are ſufficiently known without enumeration. As to the medicinal virtues attributed to gold, it is admitted by all phyſicians of reputation, that they are imaginary, and that the effects of the different kinds of potable gold propoſed by the alchemiſts, ariſe from the ſubſtances in which the metal has been mixed or diſſolved.

NOTES ON CHAPTER XXI.

GOLD.

a If gold leaf be ſhut up in cloſe veſſels with oxygenated muriatic acid gas, the gold ſoon diſappears, and is converted into a yellow fluid. On opening the veſſel it will be found that the gas has abſorbed. Scherer obſerved, that concentrated oxygenated muriatic acid occaſioned an immediate inflammation, on coming into contact with gold leaf. See *Gren's Jour. der Phyſ.* B. VIII. ſ. 375.

b Though the oxygenated muriatic, or nitro-muriatic acids, are to be conſidered as the proper ſolvents of gold, yet the oxyd of that metal combines readily with ſome of the other acids, and forms with them metallic neutral ſalts, the properties of which have been hitherto but little inveſtigated.

The ſulphat, nitrat, and muriat of gold are ſaid to be incryſtallizable. The borat is unknown. The phoſphat melts by heat into a beautiful clear red glaſs. Phoſphoric acid, according to Margraaf, precipitates gold in its metallic ſtate by long ſtanding, from its ſolution in aqua regia. The tartaric acid diſſolves oxyd of gold, but the ſalt which it forms is unknown. Oxalat of gold is inſoluble in water. The citrat and malat of gold have not been examined. Benzoat of gold has been obtained in the form of irregular cryſtals, which are difficultly ſoluble in water, and remain unchanged in the air. The acetat and ſuccinat of gold are little known. Pruſſiat of potaſh precipitates gold from its ſolution in aqua regia, but an exceſs of the pruſſiat rediſſolves the precipitate. *Gren's Handbuch. Gold.*

[c] Mr. Tennant, in the courſe of his experiments on the diamond, had occaſion to obſerve, that when that ſubſtance was not in ſufficient quantity to ſupply the alkali of the nitre with carbonic acid, a portion of the gold was diſſolved. This obſervation induced him to put ſome thin pieces of gold into the tube, together with nitre, and to expoſe them to a ſtrong red heat for two or three hours. About 60 grains of gold were found to have been diſſolved. Upon the addition of water about 50 grains of the gold were precipitated in the form of a black powder. The greater part of this precipitate was in its metallic ſtate. The gold remaining in the ſolution communicated to it a light yellow colour. It was precipitated, firſt of a deeper yellow, then of a green, and at laſt of a blue colour, by the addition of diluted ſulphuric, or nitric acids. Mr. Tennant attributes the change of colour to the gradual precipitation of the gold in its metallic form. While in ſolution, it exiſted in the ſtate of an oxyd. *Morveau Elem. de Chem.* Tom. II. p. 189. *Bergman, Opuſcul.* Tom. II. p. 189. *Encyclop. Method.* Tom. I. p. 176.

[d] Phoſphorus unites by fuſion with gold. Pelletier ſucceeded in effecting this combination, by melting together, in a covered crucible, four parts of gold duſt with eight of glaſſy phoſphoric acid, and one of charcoal. The phoſphure is paler, whiter, and more brittle than gold. This combination may be decompoſed by roaſting it in an open fire.

CHAPTER XXII.

CONCERNING PLATINA.

PLATINA, which has not been known as a peculiar metal for more than forty years, has been hitherto found only in the gold mines of America, more eſpecially in thoſe of Santa Fé, near Carthagena, and in the Bailiwick of Choco in Peru. The Spaniards give it this name from the word *plata*, which ſignifies ſilver in their language, by way of compariſon to that metal, whoſe colour it imitates. The name of *white gold*, however, appears to agree better with its properties than that of *little ſilver*, becauſe it in fact reſembles gold much more than ſilver in moſt of its properties. Some toys made of platina were in exiſtence before the time we have cited; but as this metal cannot be melted and wrought alone, it is probable that the ſnuff boxes, heads of canes, and other utenſils of this kind, which were ſold under the name of platina, were alloys of this metal with certain metallic ſubſtances, which might give it fuſibility, as we ſhall ſee in the hiſtory of its alloys.

The platina, in mineralogical collections, has the form of ſmall grains, its plates of a blueiſh black, whoſe colour is intermediate between thoſe of ſilver and iron. Theſe grains are mixed with many foreign ſubſtances; they contain ſmall particles of gold, blackiſh ferruginous ſandy grains, which by the magnifier appear ſcorified, and certain particles of mercury; the mercury is ſeparated from this mixture by heating; waſhing carries off the ſand, and grains of iron, which may likewiſe be ſeparated by the magnet; after which the particles of gold and grains of platina only remain, which are eaſily ſeparated according to Margraaf. If the grains of platina be examined by the magnifier, ſome appear angular, others round and flat, like a kind of button. When beat on the anvil, moſt of them are flattened, and appear ductile; ſome break into ſeveral pieces; the latter examined more narrowly, appear to be hollow, and particles of iron and a white powder has been found within them. The property of being attracted by the magnet, which theſe grains poſſeſs, though accurately ſeparated from the ferruginous ſand they contain, muſt doubtleſs be attributed to a portion of iron contained within them.

The hardneſs of this metal nearly approaches to that of iron; the ſpecific gravity of platina, mixed with all the foreign matters we have ſpoken of, nearly approaches to that of gold; it loſes in water between one ſixteenth and one eighteenth of its weight. Buffon and Tillet compared together an equal volume of platina, and of gold reduced into particles ſimilar to thoſe of the platina, and found that the ſpecific gravity of the former was about one twelfth leſs than the gold. Late experiments have ſhown, that platina exceeds gold in weight, when it has been purified by a long fuſion[a].

It is not probable that platina exiſts in its ores in the ſame form as it comes to us, but that its granular or plated figure is produced by the motion of the waters by which it is carried from the mountains to the plains. It has been ſometimes found in maſſes of conſiderable magnitude; the ſociety of Biſcay poſſeſs one of the ſize of a pigeon's egg. As it is found in the neighbourhood of gold mines, it is always mixed with a quantity of this metal. The mercury it contains is part of that uſed in extracting the gold. Though toys made of platina have been long ſold, this metal was not diſtinguiſhed as a peculiar ſubſtance till lately: the workmen paid no particular attention to it, and appear to have ſet no value on it, becauſe of its dull aſpect, and the difficulty of treating it. The firſt perſon who paid any particular attention to platina, was a Spaniſh mathematician, Don Antonio Ulloa, who accompanied the French Academicians in the celebrated expedition to Peru, for determining the figure of the earth. This philoſopher gives a curſory account of it in the relation of his voyage, publiſhed at Madrid in the year 1748. Charles Wood, an Engliſh metallurgiſt, brought a quantity of this metal from Jamaica in the year 1741, which he afterwards examined, and gave an account of his experiments in the Philoſophical Tranſactions for the years 1749 and 1750: at this era, the greateſt chemiſts in Europe appeared emulous in their inquiries reſpecting this new metal, which promiſed, by its ſingular properties, ſuch conſiderable advantages. Scheffer, a Swediſh chemiſt, publiſhed his experiments on platina in the Memoirs of the Academy of Stockholm, in the year 1752. Lewis, an Engliſh chemiſt, made a connected and almoſt complete ſeries of experiments on this metal, which may be found in the Philoſophical Tranſactions for the year 1754. Margraaf has inſerted in the Memoirs of the Academy of Berlin for 1757, an account of his experiments on this new metal. Moſt of theſe Memoirs were collected by Morin, in a work entitled *La platine, L'or blanc, ou le huitième métal, Paris* 1758. At the ſame time Macquer and Baumé made, in conjunction, a great number of important experiments on platina, which were publiſhed in the Memoirs of the Academy for the year 1758. Buffon has given an account in the firſt volume of the Supplement to his Natural Hiſtory, of a ſeries of inquiries reſpecting platina made by himſelf, Morveau, and the Count de Milly. The Baron Sickengen has likewiſe made a ſeries of experiments on this metal; his work has not yet been publiſhed in French, but Macquer has given an extract of it in his Dictionary of Chemiſtry. Rome de Liſle has communicated to the academy certain experiments made by himſelf on platina. The ſcarcity of this metal, and the difficulties attending the experiments made on it, ſtopped for a time the progreſs of inquiries, but within the laſt few years they have been reſumed with new ſpirit. Bergman, Achard, and Morveau, have exerted themſelves in the examination of the properties of this metal.

Platina purified and ſeparated by waſhing, trituration, and by the muriatic acid, from the foreign bodies it may contain, and afterwards expoſed to the moſt violent heat of a furnace, is not altered, but its parts ſlightly adhere together. All the chemiſts, who have made experiments on this metal, agree in this reſpect. Macquer and Baumé kept it for ſeveral days expoſed to the continual fire of a glaſs-houſe, without any other alteration, than that its grains were ſlightly adherent to each other; but this agglutination was ſo ſlight, that they ſeparated even by touching. They obſerved, that in theſe experiments the colour of the platina became brilliant by a white heat; that it acquired a dull and greyiſh colour after it had been heated a long time; and laſtly, that its weight was conſtantly increaſed as Margraaf had aſcertained, which could only ariſe from oxydation. Theſe chemiſts expoſed platina to the focus of a large burning mirror; it firſt ſmoked, then emitted very lively ſparks, and laſtly, thoſe portions which were expoſed to the centre of the focus, melted in the ſpace of a minute. The melted portions were of a white brilliant colour, in the form of a button; they could be cut into pieces with a knife; one of theſe maſſes was flattened on the anvil, and converted into a thin plate, without cracking or breaking, but it became hard under the hammer. This valuable experiment ſhows, that platina is fuſible by a fire of the utmoſt violence; that it is as malleable as gold and ſilver, and that it is ſcarcely alterable by the action of fire; for in all theſe experiments, moſt of which were made in the open air, the platina exhibited no appearance of oxydation. Morveau has likewiſe ſucceeded in melting platina in the wind furnace deſcribed by Macquer, by means of his own reducing flux, compoſed of eight parts of pounded glaſs, one part of calcined borax, and half a part of charcoal in powder. Small portions alone, and without addition, are now very eaſily melted, by heating them on a lighted charcoal, with a ſtream of vital air; but theſe ſmall ductile globules cannot be applied to any uſe, on account of their inconſiderable ſize.

Platina, when expoſed to air, is not at all changed; it is not however known what alteration it may be ſuſceptible of, if kept red hot for a long time with contact of air; perhaps it might be oxydated, as Junker affirms gold and ſilver are, when treated in the ſame manner.

This metal is not altered by water, earthy matters, the ſalino-terreſtrial ſubſtances, or by alkalis. The moſt concentrated ſulphuric acid, and the ſtrongeſt and moſt fuming nitric and muriatic acids, do not act on platina, even when boiling; neither is diſtillation, which is known to be ſo efficacious in promoting the action of acids on metallic ſubſtances, of any advantage in the preſent caſe. The ſulphuric acid ſimply tarniſhes the grains of platina, according to Lewis and Baumé; the nitric acid, on the contrary, renders them brittle. Margraaf affirms, that towards the end of the diſtillation of this acid from platina, he obtained a ſmall quantity of arſenic, a phenomenon not obſerved by other chemiſts. The muriatic acid produced no change whatſoever in grains of platina. Margraaf likewiſe obtained from this acid, diſtilled from the metal, a white ſublimate, which appeared to him to be arſenic, and a reddiſh ſublimate, whoſe properties he could not examine on account of its being in ſo ſmall a quantity. All theſe appear, however, to be foreign to the platina itſelf: this metal therefore reſembles gold by the ſlight action of the ſimple acids upon it; but the analogy is ſtill more evident by its ſolubility in the oxygenated muriatic acid, and in nitro-muriatic acid.

The firſt of theſe acids diſſolves platina with facility, and without the aſſiſtance of a ſtrong heat; ſeventy or eighty degrees of heat in the atmoſphere being ſufficient to facilitate this ſolution, which takes place without any ſenſible effervеſcence, and in other reſpects does not differ from the following.

The nitro-muriatic acid beſt adapted to diſſolve platina is compoſed of equal parts of the muriatic and nitric acids. To effect this ſolution, which in general is leſs eaſily performed than that of gold, one ounce of platina muſt be put into a retort, on which a pound of nitro-muriatic acid, in the proportions here mentioned, muſt be poured; the retort is then to be placed on a ſand bath, with a receiver applied; as ſoon as the acid is hot, a few bubbles of nitrous gas are extricated, and the action of the mixed acid proceeds without violence or rapidity. The colour of the fluid becomes at firſt yellow, afterwards orange, and at laſt of a very deep brown. When the ſolution is finiſhed, reddiſh and black particles of ſand are found at the bottom of the retort, from which the ſaturated liquor is to be ſeparated by decantation: ſmall irregular cryſtals of a duſky colour are gradually depoſited, which conſiſt of a combination of the acid and platina. The ſolution of platina is of a deeper colour than that of any other metal. Though it appears of a dark brown, yet, if it be diluted with water, it aſſumes firſt an orange colour, which ſoon becomes yellow, and reſembles the ſolution of gold: it tinges animal matters of a blackiſh brown, not at all inclining to purple. Baumé affirms, that platina fuſed in the focus of a burning mirror, and diſſolved in aqua regia, does not aſſume a brown colour, like that of platina in grains, but that the ſolution is of a deep orange yellow colour.

Macquer affirms, that by evaporating and cooling the ſolution of platina, much larger and more regular cryſtals are obtained, than thoſe ſpontaneouſly depoſited by the ſaturated fluid. Lewis having left this ſolution to evaporate in the open air, obtained cryſtals of a deep red, of a moderate ſize, irregularly formed, and reſembling the acid of benzoin, though thicker: Bergman deſcribes it as being of an octahedral form. This ſalt is ſharp, but ſcarcely cauſtic; it melts in the fire, the acid being diſſipated, and a reſidue is left in the form of an obſcure grey oxyd. Concentrated ſulphuric acid occaſions a precipitate of a deep colour, which, doubtleſs, is a ſulphat of platina; the muriatic acid, in a certain time, produces a yellowiſh depoſition.

Alkalis and the ſalino-terreſtrial ſubſtances decompoſe the ſolution of platina, and precipitate the metal in the form of an oxyd: the carbonat of potaſh produces an orange coloured precipitate in the ſolution of platina, which is not a pure oxyd. Macquer and Baumé have obſerved that its colour is owing to a certain quantity of acid it contains. It muſt therefore be conſidered as a mixture of a portion of the oxyd of platina, with muriat of potaſh, or as a kind of triple ſalt. This opinion is proved by waſhing the precipitate with hot water; for the fluid then becomes coloured by diſſolving the ſalt of platina, and the reſidue, which is a pure oxyd of the metal, is grey. Fixed alkali, boiled on this precipitate, quickly deprives it of its colour, and leaves an oxyd of platina, which is of a pearl colour, according to the experiments of Baumé: this chemiſt was convinced that the precipitate of platina is ſoluble in the alkali, becauſe a ſolution of the metal, dropped into an hot ſolution of carbonat of potaſh, afforded no precipitate. For this reaſon it is that the ſolution precipitated by fixed alkali always retains a deep colour, and affords platina by evaporating it to dryneſs. Margraaf has diſcovered that ſoda does not precipitate the ſolution of platina, but Bergman has obſerved, that on the addition of a conſiderable quantity of that alkali a precipitate is readily afforded.

Alkaline pruſſiats form an abundant blue precipitate, which, according to Baumé, ariſes from the iron contained in the alkali; ſince pruſſiat of potaſh, deprived of the iron it contains by the proceſs directed by that chemiſt, does not afford more than a few particles of blue, with the ſolution of platina, which ariſe from the ſmall portion of iron always contained in that metal. Bergman affirms that the alkaline pruſſiat, well ſaturated and very pure, does not precipitate the ſolution of platina; and that this metal is the only one not precipitated by the reagent; he, therefore, propoſes this lixivium to ſeparate from it the iron which it always contains.

The cauſtic ammoniac precipitates platina of an orange yellow: this precipitate is almoſt entirely ſaline; water diſſolving the greateſt part, and becoming coloured like a ſolution of gold. After the action of water on this precipitate, a blackiſh ſubſtance, which appears to be ferruginous, remains. The precipitate of platina by ammoniac differs from that of gold in its not poſſeſſing the fulminating property of the latter.

Nut-galls precipitate the ſolution of platina of a deep green colour, which gradually becomes lighter by ſtanding.

All the precipitates obtained from the ſolution of platina by the addition of alkaline ſubſtances, are not capable of being vitrified, or of colouring glaſs. In the trials of Lewis and Baumé, on this ſubject, the platina was conſtantly reduced in grains, in ramifications, or a kind of checquer work. A ſort of button of platina may be obtained by expoſing theſe precipitates to a ſtrong heat, with certain reducing fluxes, as borax, cream of tartar, glaſs, &c. Macquer and Baumé ſucceeded in this manner by a forge fire, urged by two pair of ſtrong bellows, to melt in thirty-five minutes a precipitate of platina mixed with fluxing ſubſtances: they obtained, beneath a hard blackiſh glaſs reſembling that of bottles, a button of platina, which appeared to have been well fuſed: this button was not ductile, but broke into two pieces, and appeared to be hollow; its fracture was grained, and its hardneſs nearly equal to that of forged iron, as it made deep traces in gold, copper, and even in iron. Though we have affirmed that the precipitates of platina do not appear to be vitrifiable or capable of tinging glaſs, yet Baumé has ſucceeded in melting them into a vitriform ſubſtance by two different proceſſes. The precipitate of platina, mixed with calcined borax, and a very fuſible white glaſs, was expoſed for thirty-ſix hours in the hotteſt part of a potter's furnace, and afforded a greeniſh glaſs, inclining to yellow, without globules of reduced metal. This glaſs, treated a ſecond time with cream of tartar, gypſum, and vegetable alkali, was completely melted, and exhibited globules of platina diſperſed through their ſubſtance. Baumé ſeparated them by waſhing, and found them ductile. The ſame chemiſt afterwards, together with Macquer, expoſed precipitate of platina to the ſame burning mirror with which they had fuſed the metal: the precipitate exhaled a very thick and luminous fume, with a ſtrong ſmell of nitro-muriatic acids; it loſt its red colour, reſumed that of platina, and melted into a perfect brilliant button, which was found to be an opake vitreous ſubſtance, of an hyacinthine colour at its ſurface, and blackiſh within, and may be conſidered as a true glaſs of platina. It may however be obſerved, that the ſaline matters with which it was impregnated, contributed doubtleſs to its vitrification.

The precipitate of platina does not appear to be ſoluble in ſimple acids, but it diſſolves very well in nitro-muriatic acid, to which it gives an orange colour, not at all reſembling the brown colour exhibited by the platina in grains.

The ſolution of platina is not precipitated by the alkaline or perfect neutral ſalts; but ammoniacal muriat precipitates it abundantly. The rationale of this experiment is not well decided. The orange-coloured precipitate obtained by pouring a ſolution of ammoniacal muriat into a ſolution of platina, appears to be a ſaline ſubſtance, entirely ſoluble in water; this precipitate has a valuable property, diſcovered by De Liſle, viz. that it is fuſible, without addition, in a good furnace, or common forge heat. The platina melted by this proceſs is a brilliant, denſe, and cloſe grained button; but it is not malleable, unleſs it has been expoſed to a very ſtrong heat. Macquer thinks that this fuſion, like that of the grains of platina expoſed alone to the action of a violent fire, conſiſts only in the agglutination of the ſoftened particles, which being exceedingly more divided and minute than the grains of platina, adhere to and touch each other in a greater number of points than the grains; and in that manner render the texture of the metal much more cloſe, though no true fuſion may have taken place. It ſeems, however, that if platina, in grains, be capable of fuſion by the burning glaſs, and of becoming conſiderably ductile, the precipitate of this metal made by ammoniacal muriat, may likewiſe be fuſed on account of its extreme diviſion; and that its not being as ductile as the button of platina fuſed by the ſolar heat, may perhaps depend on its ſtill retaining a part of the matter it carried down with it in its precipitation, of which it may be poſſible to deprive it by fire.

Margraaf diſſolved platina in *aqua regia*, compoſed of ſixteen parts of nitric acid, and one of ammoniacal muriat; by diſtilling this ſolution to dryneſs, and heating the bottom of the retort till it was red, a ſalt of a deep red colour was ſublimed, and the reſidue was in the form of a reddiſh powder. It is not known whether the ſolution of platina in ſimple *aqua regia*, made with the nitric and marine acids, will afford a ſublimate of the ſame kind by diſtillation.

Margraaf, Baumé, and Lewis, mixed the ſolution of platina with ſolutions of all the other metallic ſubſtances; the reſult of their experiments was, that almoſt all the metals precipitate platina in the form of a brick-duſt coloured powder, and that none of theſe precipitates poſſeſs the metallic properties, as happens with moſt of the other metals. This exhibits another analogy between gold and platina, though the latter does not afford a purple precipitate with tin, but a brown precipitate, inclining to red. With regard to the effect of the different metallic ſolutions on that of platina, it need only be obſerved, that the ſolutions of biſmuth and lead by the nitric acid, of iron and copper by different acids, and of gold by aqua regia, do not produce any precipitate in that of platina, according to Margraaf; but that, on the contrary, thoſe of the arſeniat of potaſh, of the nitrats of zink and of ſilver, precipitate it; the firſt in the form of a cryſtallized ſubſtance, in ſmall quantity, and of a beautiful gold colour; the ſecond in a red orange coloured matter, and the third in a yellow matter. Theſe different precipitates have not yet been well examined; and the decompoſition by which they are occaſioned is unknown.

Moſt of the neutral ſalts have no action on platina. Margraaf heated platina by a ſtrong fire, with ſulphat of potaſh and ſoda; theſe ſalts melted, and the platina remained in grains without alteration: it only communicated a ſlight reddiſh colour to the ſaline ſubſtances, doubtleſs on account of the iron communicated by the metal to them.

Nitre produces a ſingular alteration in platina, according to the experiments of Lewis and Margraaf. Though no detonation is produced when a mixture of both ſubſtances is thrown into a red hot crucible; yet, by a ſtrong heat long continued, ſuch as Lewis applied for three ſucceſſive days and nights to a mixture of one part of platina and two of nitre, the metal becomes of a ruſty colour. If the mixture be boiled in water, the fluid diſſolves the alkali, which takes up the browniſh powder, and the platina ſeparated from the liquid is found diminiſhed more than one third of its weight. The brown powder taken up by the alkali may be ſeparated by filtration. It appears to be a kind of oxyd of platina, mixed with a ſmall quantity of oxyd of iron. Lewis converted this oxyd to a whitiſh grey colour, by diſtilling it a great number of times with ammoniacal muriat. Margraaf, who repeated this experiment, adds two important facts; the firſt is, that platina, combined with the alkali of nitre, and diluted in a certain quantity of water, forms a jelly; and the other, that by heating the portion of metal ſeparated from the jelly, diluted with water and filtrated, it becomes of a black pitchy colour. This experiment certainly ſhows a great alteration of the platina, and requires to be continued, in order to decide whether, by virtue of repeated oxydations with nitre, it be poſſible to reduce the whole of the metal into a brown powder, and eſpecially to determine the ſtate of the platina thus oxydated.

The muriats of potaſh and of ſoda, borax, and the earthy ſalts, produce no change in platina, nor facilitate its fuſion; ammoniacal muriat, diſtilled with this metal, affords a ſmall quantity of *martial flowers* by virtue of the iron it contains [b]. Chemiſts are not agreed reſpecting the mutual action of arſenic and platina. Scheffer firſt aſſerted, that arſenic cauſes this metal to enter into fuſion; but the experiment ſucceeded but imperfectly in the hands of Lewis, and not at all with Margraaf, Macquer, and Baumé. This experiment has been ſince repeated, and it appears that platina is in fact very fuſible with arſenic, but that it remains brittle. In proportion as the arſenic is driven off by a continuance of heat, it becomes more ductile, and by this proceſs it is, that Achard and Morveau ſucceeded in making crucibles of platina, by melting it a ſecond time in moulds. No one has attempted to combine cobalt, nickel, or manganeſe with platina.

This perfect metal unites very well with biſmuth, which renders it ſo much the more fuſible, as the quantity of the latter is greater ; the alloy is brittle, and becomes yellow, purple, and blackiſh in the air. This mixed metal cannot be cupelled without the greateſt difficulty, and never forms a maſs of any conſiderable ductility.

Platina fuſes readily with antimony, and produces a brittle metal of a plated texture, from which the antimony may be ſeparated by the action of fire, though not ſo completely, but that the platina always retains a ſufficient quantity to render it defective in weight and ductility.

Zink renders platina very fuſible, and combines readily with it ; this alloy is brittle, and difficult to file ; its colour is blueiſh. When the platina is moſt abundant, theſe two metallic ſubſtances are ſeparated by the action of fire, which volatilizes the zink, though the platina always retains a ſmall portion.

Platina does not unite with mercury, though triturated for ſeveral hours with that metallic fluid. It is likewiſe known that platina reſiſts the mercury uſed in America to ſeparate the gold. Many intermediums, ſuch as water, uſed by Lewis and Baumé, and nitro-muriatic acid by Scheffer, have not been found to facilitate the union of theſe two metals. In this reſpect platina appears to reſemble iron, to whoſe colour and hardneſs it likewiſe in ſome reſpects approaches [c].

Platina mixes very eaſily with tin, and forms a very fuſible and fluid alloy. It is brittle, ſo as even to break by a fall when the two metals are united in equal portions. When the tin is in the proportion of twelve or more to one of platina, the mixture is conſiderably ductile, but its grain is coarſe, and it becomes yellow in the air. Platina remarkably diminiſhes the ductility of tin, and the alloy does not promiſe to be of any uſe ; yet, when it is well poliſhed, it may remain long expoſed to the air without alteration. It ſeems that Lewis, to whom we are indebted for moſt of the knowledge we poſſeſs reſpecting the alloys of platina, ſucceeded in oxydating this metal, and diſſolving it in the muriatic acid by means of tin.

Lead and platina unite very well by fuſion, but they require a ſtronger heat than the laſt mentioned alloy. Platina deprives lead of its ductility; the combination of theſe two metals is of a purpliſh colour, and brittle, according to the proportion of platina, ſtriated and granulated in its fracture, and quickly changes by expoſure to air. Cupellation with lead was one of the firſt and moſt important experiments attempted to be made with platina, becauſe this operation was expected to deprive it of the foreign metallic ſubſtances it might contain. Lewis, and ſeveral other chemiſts, have in vain attempted to cupel platina in the ordinary cupelling furnaces, though they applied a moſt violent heat. The vitrification and abſorption of the lead takes place as uſual at the commencement of the proceſs, on account of the exceſs of that metal; but the platina ſoon becomes fixed, and the operation is at an end. The metal remains united with a portion of the lead, and is not at all ductile. Macquer and Baumé ſucceeded in the perfect cupellation of platina, by expoſing an ounce of the metal, and two ounces of lead, in the hotteſt part of the porcelain furnace at Seves. The wood fire laſts for fifty hours ſucceſſively; at the end of this time the platina was found flattened on the cupel; its upper ſurface was dull and rough, and eaſily ſeparated; its under ſurface was brilliant, and, what is the moſt valuable, it was eaſily extended under the hammer. Theſe chemiſts were convinced, by every poſſible method, that the platina did not contain lead, but was very pure. Morveau likewiſe ſucceeded in cupelling a mixture of one drachm of platina, and two drachms of lead, in the wind furnace of Macquer: this operation, made at four ſucceſſive times, laſted eleven or twelve hours. Morveau obtained a button of platina, not adhering to the cupel, uniform, of a colour reſembling tin, but rather rough, which weighed exactly one drachm, and was found to be not at all acted on by the magnet. This proceſs appears to be excellently adapted for obtaining platina in plates or laminæ, which may be forged, and conſequently may be employed in making various utenſils of great value, with reſpect to hardneſs and unchangeableneſs. Baumé has likewiſe obſerved another very uſeful property, viz. that of welding and forging together, like iron, without the aſſiſtance of any other metal. After having heated two pieces of platina to whiteneſs, which had been cupelled in the furnace of Seves, he placed them one on the other, and ſtriking them briſkly with the hammer, they welded together as quickly and firmly as two pieces of iron would have done. The great importance of this experiment, with reſpect to the arts, need not be inſiſted on.

Macquer could not obtain an alloy with forged iron and platina: this mixed metal would poſſeſs the great advantage of uniting the hardneſs of ſteel with a conſiderable ductility, or at leaſt it would not be brittle like ſteel. The Engliſh chemiſt we have quoted melted a mixture of caſt iron and platina; the alloy was ſo hard as not to be touched by the file; it had a ſlight degree of ductility, but broke ſhort when ignited.

Platina communicates hardneſs to copper, with which it melts with conſiderable facility: this alloy is ductile, when the doſe of copper is three or four times greater than that of platina; it is capable of taking the moſt beautiful poliſh, and was not tarniſhed in the air during the ſpace of ten years.

Platina partly deſtroys the ductility of ſilver, augments its hardneſs, and impairs its colour. This mixture is very difficult to fuſe; by fuſion and reſt the two metals are ſeparated. Lewis obſerved, that ſilver melted with platina was thrown up againſt the ſides of a crucible with a kind of exploſion; a property which appears to belong to ſilver alone; for D'Arcet has obſerved that this metal breaks balls of porcelain, in which it is encloſed, and is thrown out by the action of the fire.

Platina does not readily combine with gold, but by the help of a very ſtrong fire. It greatly alters the colour of this metal, unleſs its quantity be very ſmall; thus, for example, a forty-ſeventh part of platina, and all the proportions below that, do not greatly change the colour of gold. Platina does not much impair the ductility of gold, which is leſs affected than any other metal by the admixture. The ſpecific gravity of platina being ſuperior to that of gold, might give riſe to frauds; and for this reaſon the Spaniſh miniſtry have prohibited its exportation: however, ſince chemiſtry has diſcovere methods for diſtinguiſhing the alloy of gold with platina, and even of platina alloyed with gold, theſe fears ought no longer to be attended to; and it is much to be deſired that platina may no longer be prohibited, but that this new metal, which promiſes ſuch conſiderable advantages to ſociety, may become an article of commerce.

The ſolution of ammoniacal muriat, as we have obſerved, has the property of precipitating platina; if, therefore, gold be ſuſpected to be alloyed with platina, its ſolution in *aqua regia* may be aſſayed with a ſolution of ammoniacal muriat. The ſmall quantity of platina it contains will occaſion an orange or reddiſh precipitate; if no precipitate is thrown down, the gold does not contain platina. If it ſhould happen that the valuable properties of platina ſhould at ſome future time render it more ſcarce and valuable than gold, it will not be in the power of avarice to deceive us in alloying it with gold, ſince a ſolution of ſulphat of iron, which has the property of precipitating the ſolution of gold without producing any change in that of platina, would immediately expoſe the deception. A piece of tin, plunged in a ſolution of platina alloyed with gold, would likewiſe ſhow the preſence of the latter, by becoming covered with a purple precipitate; whereas platina gives only a dirty brown precipitate, of a reddiſh colour: this laſt precipitate likewiſe does not colour glaſs, whereas the precipitate of gold gives it a purple colour.

All the properties of platina which we have examined appear to prove that this ſubſtance is a peculiar metal: its want of ductility and fuſibility, which have been conſidered by ſome writers as ſtrong objections to this opinion, are not capable of overthrowing it, ſince there is perhaps a leſs difference between the fuſibility of platina and forged iron, than between that of forged iron and lead, and ſince its want of ductility ariſes from its not having undergone complete fuſion. As to the opinion of thoſe philoſophers who conſider platina as a natural alloy of iron and of gold, however ingenious and ſatisfactory it may appear, it is impoſſible to admit it, until the metal has been ſeparated into the two others by an accurate analyſis, and until platina can be better imitated by the artificial alloy of gold and iron. Laſtly, Macquer has made a very ſtrong objection againſt this laſt opinion, by obſerving, that the more platina is deprived of the iron it contains, the greater is the difference between its external appearances and thoſe of gold.

The important uſes to which this precious metal may be applied will be eaſily conceived, when it is conſidered that it unites the indeſtructibility of gold to a degree of hardneſs almoſt equal to that of iron; that it reſiſts the action of the moſt violent fire, and alſo of the moſt concentrated acids. It cannot be doubted but that chemiſtry and the arts would be in the higheſt degree benefited by its being applied to uſeful purpoſes.

NOTES ON CHAPTER XXII.

PLATINA.

a THE ſpecific weight of this metal, as aſcertained by Morveau, is 20,847.

b Morveau ſucceeded in partially oxydating the ſurface of a plate of platina, by keeping it in a red heat, and by projecting upon it oxygenated muriat of potaſh. The ſalt did not detonate, but it was volatilized with a reſidue. *Ann. de Chem.* Tom. XXV. p. 1.

c A recent experiment of Morveau's ſeems to ſhow that platina, in the uſual temperature, amalgamates by long contact with mercury, though very ſlowly indeed, and in a very weak degree. This union, however, is greatly aſſiſted by heat. Morveau found that the platina, like gold, was diſpoſed to oxydation in conſequence of its union with mercury.

CONCERNING CHROME.

Vauquelin has diſcovered a new metal in the red lead of Siberia, to which he has given the name of *chrome*. The following account of its properties, and the proceſs for obtaining it, is taken from the 25th volume of the *Annalles de Chemie*.

Experiment I. A hundred parts of this mineral (red lead), reduced to a fine powder, were mixed with 300 parts of the ſaturated carbonat of potaſh, and about 4000 parts of water, and this mixture was expoſed for an hour to a boiling heat. I obſerved, 1ſt, That when theſe matters began to act upon each other, a lively efferveſcence was produced, which continued a long time; 2d, That the orange colour of the lead became a briſk red; 3d, That at a certain period the whole matter ſeemed to be diſſolved; 4th, That in proportion as the efferveſcence went on, the matter reappeared under the form of a granulated powder, of a dirty yellow colour; 5th, That the liquor aſſumed a beautiful golden yellow colour. When the efferveſcence had entirely ſubſided, and when the ſubſtances ceaſed to act on each other, the liquor was filtered, and the metallic powder collected on the paper. After being waſhed and dried, it weighed no more than 78 parts; the potaſh therefore had taken up 22 parts.

Experiment II. I poured upon the 78 parts juſt mentioned ſome nitric acid diluted with 12 parts of water. A briſk efferveſcence took place; the greater part of the matter was diſſolved; the liquor did not become coloured; and there remained only a ſmall quantity of powder, of a citron yellow colour. I ſeparated the liquor of the reſiduum by the help of a ſyphon, waſhed the matter ſeveral times, and united the waſhings with the firſt liquor. This reſiduum dried weighed no more than 14 parts, from which it followed that the nitric acid had diſſolved 64.

Experiment III. I again mixed theſe 14 parts with 42 parts of the carbonat of potaſh, and the neceſſary quantity of water. I then treated them as in experiment 1ſt, and the phenomena were the ſame. The liquor, after being filtered, was united to the former, and the reſiduum, waſhed and dried, weighed no more than two parts, which were ſtill red lead, and therefore thrown away.

Experiment IV. The two nitric ſolutions united and evaporated afforded 92 parts of the nitrat of lead, cryſtallized in octahedrons, perfectly white and tranſparent. Theſe 92 parts of nitrat of lead diſſolved in water were precipitated by a ſolution of ſulphat of ſoda. By this, 81 parts of the ſulphat of lead were produced, which are equivalent to 56,68 of metallic lead.

Experiment V. The alkaline liquors united had a citron yellow colour. They depoſited, at the end of ſome days, two parts of a yellow powder, which did not contain any lead. Theſe liquors, ſubjected to evaporation till a ſaline pellicle was formed on their ſurface, afforded, by cooling, yellow cryſtals, among which there was carbonat of potaſh undecompoſed. Theſe cryſtals being diſſolved in water, the ſolution united to the mother water was mixed with weak nitric acid until the carbonat of potaſh was ſaturated. The liquor had then a very deep orange red colour. Being mixed with a ſolution of the muriat of tin newly made, it firſt aſſumed a brown colour, which afterwards became greeniſh. Mixed with a ſolution of the nitrat of lead, it immediately produced the red lead. Laſtly, Evaporated ſpontaneouſly, it produced ruby-red coloured cryſtals mixed with cryſtals of the nitrat of potaſh. 98 parts of this mineral decompoſed as above mentioned having afforded 81 parts of the ſulphat of lead, 100 parts would have given 82,65, which are equivalent to 57,1 of the metallic lead. But admitting, as experiment proves, that 100 parts of lead abſorb, in combining with acids, 12 parts of oxygen, the 57,1 of metallic lead ought to contain in the red lead 6,86 of this principle, and we ought to have for the mineralizing acid 36,4.

Experiment VI. To verify by ſyntheſis the proportion of the principles of the red lead found by analyſis, I diſſolved about 50 grains of metallic lead in the nitric acid, and the ſolution being divided into two equal parts, one of them was completely precipitated by the neceſſary quantity of the combination of the acid of red lead with potaſh, and 43 grains of red lead were obtained, as beautiful as the native mineral. The other portion of the nitrat of lead, precipitated by cauſtic potaſh, gave 28 grains of the white oxyd of lead; ſo that by this ſyntheſis 100 parts of red lead are compoſed of 65,12 of the oxyd of lead, and 34,88 of acid. By analyſis, as has been ſhown, it affords only 1,72 * leſs in the acid which mineralizes the red lead; a difference which approaches as near to correctneſs as chemical means will admit †.

Though the properties which have been explained are, ſtrictly ſpeaking, more than ſufficient to convince any one well acquainted with the differential characters of metallic ſubſtances that the one in queſtion belongs to a particular ſpecies, I thought it my duty to compare its acid by a ſeries of combinations with the molybdic acid, in ſome of the properties of which it ſeems to participate.

The combination of the molybdic acid with potaſh affords a ſalt which has no colour.

The combination of the acid of red lead with potaſh gives a ſalt of an orange colour.

A. Molybdic acid, mixed with filings of tin and the muriatic acid, immediately becomes blue, and precipitates flakes of the ſame colour, which diſappear at the end of ſome time, if an exceſs of muriatic acid has been added, and the liquor aſſumes a browniſh colour.

B. Acid of red lead, treated in the ſame manner, becomes at firſt yellowiſh brown, and afterwards aſſumes a beautiful green colour.

A. Mixed with a ſolution of hydro-ſulphure of potaſh, gives no precipitate; but by the addition of ſome drops of the nitric acid, there is immediately formed a precipitate of a cheſnut brown colour.

B. Mixed with the ſame reagent, gives, without the addition of the nitric acid, a green precipitate, which by that acid becomes yellowiſh.

A. With a ſolution of the nitrat of lead, forms a white precipitate, ſoluble in the nitric acid.

B. Mixed with the ſame ſolution, gives an orange coloured precipitate, abſolutely of the ſame ſhade as that of the red lead pulverized.

A. Mixed with a little alcohol and nitric acid, does not change its colour.

B. Added to the ſame reagent, immediately aſſumes a blueiſh green colour, which preſerves the ſame ſhade even after deſſication. Ether alone gives it the ſame colour.

A. With a ſolution of the nitrat of mercury, gives a white flaky precipitate.

B. With the ſame ſolution of mercury, affords a precipitate of a dark cinnabar colour.

A. With a ſolution of the nitrat of ſilver, forms a white flaky precipitate.

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* The difference is only 1,52.

† Red lead of Siberia contains a little water, according to the experiments of Bucquet, to which perhaps this difference is owing.

B. With the ſame reagent, gives a precipitate, which, the moment it is formed, appears of a moſt beautiful carmine colour, but which becomes purple by expoſure to the light. This combination expoſed to the heat of the blow-pipe melts before the charcoal is inflamed. It aſſumes a blackiſh and metallic appearance. If it be then pulverized, the powder is ſtill purple; but after the blue flame of the lamp is brought in contact with this matter, it aſſumes a green colour, and the ſilver appears in globules diſſeminated throughout its ſubſtance.

A. With the nitrat of copper, forms a greeniſh precipitate.

B. With the ſame ſolution, gives a cheſnut red precipitate.

A. With the ſolutions of ſulphat of zink, muriat of biſmuth, muriat of antimony, nitrat of nickel, the muriats of gold and platina, produces white precipitates, when theſe ſolutions do not contain exceſs of acid.

B. With the ſame ſolutions, produces almoſt the ſame phenomena, except that the precipitates are for the moſt part yellowiſh. That of gold is greeniſh.

The molybdic acid alone melted with borax gives it a blueiſh colour.

2. Paper dipped in the molybdic acid becomes in the ſun of a beautiful blue colour.

3. The molybdat of lead diſſolves in the muriatic acid, and the ſolution does not aſſume any colour even by ebullition.

The acid of red lead alone melted with borax communicates to it a very dark green colour.

2. Paper impregnated with the acid of red lead aſſumes in the light a greeniſh colour.

3. The red lead diſſolves even without the application of heat in the muriatic acid, and the ſolution has an orange red colour; but by boiling it aſſumes a beautiful green colour, and highly oxygenated muriatic acid is formed.

From theſe phenomena, I entertain no doubt that the acid which mineralizes the red lead of Siberia has for its baſes a particular metal hitherto unknown. If, indeed, it be compared with all the other metals, no perfect analogy will be found between them. The uranium does not become acid, it cannot be combined with cauſtic alkalis, and it does not redden vegetable blue colours. Titanium diſſolves in acids, produces cryſtallizable ſalts, and does not combine with alkalis. Tungſten becomes yellow in acids without being diſſolved, and affords with alkalis white cryſtallizable ſalts. It would be endleſs to continue the compariſon of this ſubſtance with the other metals; their properties are too well known, and it is evident that they do not exhibit ſimilar phenomena.

When muriatic acid, mixed with an equal part of water, is poured on red lead, a muriat of lead is formed, which is depoſited in the form of white cryſtals, and the liquor aſſumes a beautiful orange colour. In this operation the native acid of the red lead is ſeparated, and remains diſſolved in the water of the muriatic acid. By evaporating the liquor ſlowly in the dark, cryſtals of the acid of lead are formed, which are of a ruby-red colour. But if the muriatic acid be in too great quantity, or too highly concentrated, or if the operation be conducted in a ſtrong heat, inſtead of a red acid, a deep green liquor is formed by the combination of the oxyd of the new metal with the muriatic acid.

Sulphuric acid alſo decompoſes the red lead, but it is difficult to ſeparate the products which are formed.

Nitric acid produces no change in the nature of red lead. It indeed effects a ſolution when aſſiſted by heat, but the greater part of the red lead ſeparates unaltered by cooling.

Cauſtic alkalis do not appear to decompoſe red lead; they diſſolve it entirely, and form with it a triple compound, the properties of which I have not yet fully examined.

Alkaline carbonats, on the contrary, decompoſe the red lead completely. A carbonat of lead is formed on the one hand, and, on the other, a ſoluble ſalt, compoſed of the metallic acid and the baſe of the carbonat employed.

The ſalts which this acid forms with alkalis cryſtallize into priſms or into laminæ of a golden yellow colour. I have not yet been able exactly to determine their form from the ſmallneſs of the quantity upon which I have operated.

Theſe ſalts have a ſlightly metallic taſte, and aſſume a green colour by fuſion. They are decompoſed by acids and by alkaline earths, with which they form citron yellow precipitates.

Muriatic is the only mineral acid which exerts any very remarkable action on the acid of red lead. When red lead or its acid is diſtilled with a ſomewhat concentrated muriatic acid, oxygenated muriatic acid is ſoon diſengaged, and the liquor aſſumes a beautiful green colour. In this experiment the muriatic acid takes a part of its oxygen from the acid of the lead, and reduces it to the ſtate of a green oxyd, which is held in ſolution by another portion of the muriatic acid.

A thin plate of gold was diſſolved in a ſhort time in a mixture of muriatic acid and the acid of lead. The ſolution had a yellowiſh green colour.

Sulphuric acid in the cold has no action upon this acid, but in the heat it gives to it a blueiſh green colour. This effect is undoubtedly produced by favouring the diſengagement of a portion of the oxygen of the acid from lead.

Sulphureous acid ſeizes upon a portion of the oxygen of this acid, and becomes ſulphuric acid, while the acid of lead is reduced to the ſtate of an oxyd, and diſſolved in the ſulphuric acid.

To try whether the acid of red lead could be reduced to the metallic ſtate, I put 72 parts of this acid into a crucible of charcoal, which I placed in another crucible of earth filled with powder of charcoal. I heated it for half an hour in the fire of a forge furnace. In the charcoal I found a metallic maſs of a white grey colour, formed of needles interlaced in each other, and which weighed 24 parts. The acid of red lead therefore contains a great qaantity of oxygen.

1. This metal is white-greyiſh, very brittle, infuſible, fixed, and cryſtallizes into needles.

2. Expoſed to the heat of the blow-pipe, it is covered with a lilac coloured cruſt, which becomes green by cooling.

3. Heated by the ſame apparatus with borax, it does not melt, but a part, after being oxydated, is diſſolved in this ſalt, and communicates to it a very beautiful green colour.

4. Acids have only a weak action on this metal. The nitric is the only acid which produces any remarkable change. By diſtilling to dryneſs five or ſix times ſucceſſively 20 parts of this acid concentrated upon one of metal, I was able to change it into a yellow orange coloured powder, which began to aſſume a green colour. This powder is acid; diſſolves in water; combines with alkalis, from which it diſengages carbonic acid; precipitates metallic ſolutions with preciſely the ſame phenomena as the native acid of red lead.

I have given the name of *chrome*, which ſignifies colour, to this metal, from the ſuggeſtion of Fourcroy and Hauy, becauſe all the combinations of this ſubſtance are more or leſs coloured.

The uſes of this metal are not known. Perhaps it may afford beautiful and durable colours to the painter or the enameller. I have found the oxyd of this metal in the emerald, which receives from it its colouring part.

CONCERNING URANIUM.

[a] Klaproth has diſcovered a new metal, to which he has given the name of *Uranium*, in the ſubſtance known by mineralogiſts under the names of *pechblende*, *green mica*, or *chalkolithe*. The account which this celebrated chemiſt has given of the nature and properties of this metal, has been fully confirmed by the experiments of Richter.

Uranium exiſts in nature, I. In the ſtate of an oxyd. Of this, mineralogiſts diguiſh two ſpecies.

A. The *ochre of uranium*, conſiſting of the oxyd of this metal with a greater or ſmaller portion of iron.

B. Chalkolithe, or *micaceous uranitic ore.*

II. In the ſtate of an ore, as in *pechblende mineralized with ſulphur.*

When pechblende, free from all adhering impurities, is digeſted in nitric acid the metallic matter which it contains is completely diſſolved, while part of the ſulphur remains undiſſolved, and part of it is diſſipated under the form of ſulphurated hydrogen gas. Alkalis precipitate from this ſolution the oxyd of uranium, which has a citron yellow colour when pure, but which receives a browniſh tinge from an admixture of iron.

The oxyd of uranium is fixed in the fire. It undergoes only a ſlight change of colour from expoſure on charcoal to the blow-pipe. A globule of a browniſh colour is obtained by melting it with ſoda or borax. Microcoſmic ſalt forms with it a clear green coloured glaſs.

This oxyd is reduced to the metallic ſtate with great difficulty. Saline matters ſeem to be improper for this purpoſe, in conſequence of their forming conſtantly, with this ſubſtance, black glaſſy ſlags. Klaproth obtained a metallic globule, 28 grains in weight, by forming a ball with 50 grains of the oxyd and a little wax, and by expoſing this ball in a crucible lined with charcoal, to a heat equal to the 170° of Wedgewood's pyrometer. Richter obtained, in a ſingle experiment, 100 grains of this metal, which ſeemed to be free from all admixture of foreign matter. In its luſtre and grain, it was not unlike ſteel; but it was not, like ſteel, affected by expoſure to air and moiſture. The ſpecific weight of this piece was 694. It received a beautiful poliſh, and was attracted by the magnet.

Oxyd of uranium melts with different preparations of earths and alkalis, and communicates to the glaſſes which they form, a variety of colours.

Sulphuric acid diſſolves the oxyd, but not ſo readily the metal of uranium. By evaporation, Richter obtained citron yellow coloured cubical cryſtals.

Nitric acid diſſolves readily the metal, as well as the oxyd of uranium.

Klaproth obtained from this ſolution beautiful clear ſix ſided tabular cryſtals, of about 3-4ths of an inch long, and 1-4th broad. This ſalt effloreſces when expoſed to the air.

Muriatic acid forms, with oxyd of uranium, four-ſided tabular cryſtals, of a yellowiſh green colour, which attract humidity from the air.

Fluoric acid diſſolves the oxyd of uranium, and forms with it a ſalt that is not liable to deliqueſcence.

Concentrated acetic acid diſſolves the oxyd of uranium by digeſtion. The ſolution affords, by ſlow evaporation, beautiful clear topaz coloured four-ſided priſmatic cryſtals, about an inch in length, terminated by four-ſided pyramids. After the diſſipation of the acid by heat, theſe cryſtals retained nearly the ſame form with acetat of uranium.

Phoſphoric acid combines with the oxyd of uranium, and forms with it yellowiſh white irregular flakes, which are difficultly ſoluble in water. A ſimilar precipitation is produced, by adding phoſphoric acid to a ſolution of acetat of uranium.

Tartaric acid forms with oxyd of uranium a ſalt extremely difficult to diſſolve in water. This ſalt is moſt eaſily obtained in the way of double affinity, by adding tartarit of potaſh to a ſaturated ſolution of uranium in the nitric acid. Tartarit of uranium is decompoſed by the ſulphuric, nitric, and muriatic acids.

Richter ſucceeded in combining the citric, oxalic, malic, benzoic, ſuccinic, and boracic acids, with oxyd of uranium. Theſe combinations were greatly aſſiſted by heat.

The pyrolignic acid diſſolves alſo the oxyd of uranium by the aſſiſtance of heat, and ſhoots with it into yellowiſh white plumoſe cryſtals, which are permanent in the air.

The ſebacic and formic acids unite with the oxyd of uranium, and form with it mucilaginous-like maſſes, which attract moiſture from the atmoſphere.

Arſeniat of potaſh decompoſes the nitric ſolution of uranium, and a white yellow arſeniat of uranium is precipitated.

If molybdat of potaſh be added to a ſolution of uranium in the nitric acid, a mutual exchange of baſes takes place. The molybdat of uranium which is formed is difficultly ſoluble in water, has a whitiſh yellow colour, paſſing into a browniſh. This ſalt is decompoſed by the ſulphur in nitric and muriatic acids.

The tungſtat, which may be obtained in the ſame way with the molybdat, has a browniſh white colour, and is inſoluble in water.

The gallic acid precipitates uranium from its ſolutions in acids. When the acid is in exceſs, there is only a very ſmall quantity of precipitate formed. The addition of an alkali to the acid ſolution occaſions a copious chocolate-brown precipitate.

Pruſſiat of potaſh precipitates uranium of a brown red colour, having a ſtrong reſemblance to the precipitate of copper by the ſame acid. It differs from it, however, in being diffuſed through the liquor, and not in flakes, like the precipitate of copper. Pruſſiat of uranium has alſo a ſtrong reſemblance to the pruſſiat of molybdena precipitated from ſolution in muriatic acid; but it may be eaſily diſtinguiſhed from that ſubſtance by its affinities.

The carbonats of alkalis diſſolve the oxyd of uranium, though the carbonic acid itſelf ſeems to have a very weak affinity for this oxyd. Does the ſolution of oxyd of uranium, in a carbonat of alkali, form a triple ſalt?

Oxyd of uranium is inſoluble in cauſtic fixed alkalis. It receives from them, however, a dark brown colour.

Sulphur, though found in a ſtate of combination with oxyd of uranium, ſeems to have only a weak affinity for this ſubſtance.

If a few drops of an alkaline ſulphure be added to a ſolution of uranium in nitric acid, a brown red coloured, and afterwards a black brown precipitate, is produced.

The ammoniacal ſulphure occaſions a brown yellow precipitate in the ſame ſolution, and the ſurface of the liquor is at length covered with a greyiſh metallic pellicle.

Klaproth ſuſpended bars of iron and zink in the nitric ſolution of uranium, but no precipitation of this metal took place.

Uranium amalgamates difficultly, if at all, with mercury.

Sulphuric ether aſſumes a golden yellow colour, by mixing it with a ſolution of nitrat of uranium, which has been evaporated to the conſiſtence of a ſyrup. *Klaproth Berträge* B. II. ſ. 195. *Richter ueber die neuern Gegenſtan. der Chemie*, S. I. ſ. 1. *Gren's Handbuck. Uranium.*

CONCERNING TELLURIUM.

Klaproth has diſcovered a metal abſolutely different from any hitherto known in the auriferous ore, known by the name of *aurum paradoxum*, or *problematicum*.

Proceſs for obtaining the metal from the ore:

1. The ore is gently heated with ſix parts of the muriatic acid; three parts of the nitric being then added, the mixture is boiled, upon which there ariſes a conſiderable effervеſcence, and a complete ſolution is obtained.

2. The filtered ſolution is diluted with as much water as it can bear without becoming turbid, which is a very ſmall quantity, and a ſolution of cauſtic potaſh is then added to the liquor until the white precipitate which is at firſt formed diſappears again, and nothing remains but a brown flaky ſediment.

3. This laſt precipitate is the oxyd of gold mixed with the oxyd of iron, and a ſeparation is effected by the common means.

4. The muriatic acid is added to the alkaline ſolution (2) in ſufficient quantity to ſaturate the alkali entirely. An exceſs of the acid muſt be avoided. A white precipitate, which by heat ſettles at the bottom of the veſſel under the form of a heavy powder, is produced in great abundance. After the precipitate has been waſhed and dried, it is formed into a kind of paſte with a ſufficient quantity of any fat oil, and this maſs is put into a ſmall glaſs retort, to which a recipient is ſlightly fitted. When this arrangement is made, it is gradually brought to a red heat, and in proportion as the oil is decompoſed, there are obſerved, as in the diſtillation of mercury, brilliant and metallic drops, which cover the upper part of the retort, and which at intervals fall to the bottom of the veſſel, and are immediately replaced by others. After it is cooled, metallic fixed drops are found adhering to the ſides of the retort and at the bottom of the veſſel, and the remainder of the metal is reduced and melted, with a brilliant ſurface, and almoſt always cryſtallized.

Eſſential characters of this new metal.

1. It has the white colour of tin approaching to the grey colour of lead. Its metallic ſplendor is conſiderable, and its fracture laminated. It is highly brittle and friable. By ſuffering it to cool quietly and gradually, it readily aſſumes a cryſtallized ſurface.

2. Its ſpecific gravity is 6,115.

3. It belongs to the claſs of the moſt fuſible metals.

4. When heated with the blow-pipe upon charcoal, it burns with a very lively flame, of a blue colour, inclining at the edges to a green. It is ſo volatile as to riſe entirely in a whitiſh grey ſmoke, and exhales a diſagreeable odour like that of radiſhes. On ceaſing to heat it, without having entirely volatilized the ſmall portion ſubjected to this operation, the button which remained retained for a long time its liquidity, and by cooling, it was covered with a radiated vegetation.

5. This metal amalgamates eaſily with mercury.

6. With ſulphur it forms a grey ſulphure, of a radiated ſtructure.

7. A ſolution of it in the nitric acid is tranſparent and colourleſs. When concentrated, it produces in time ſmall white light cryſtals in the form of needles, which exhibit a dendritic aggregation.

8. The new metal diſſolves in the nitro-muriatic acid. When a large quantity of water is added to ſuch a ſaturated ſolution, the metal is precipitated in the ſtate of an oxyd under the form of a white powder, which in this ſtate is ſoluble in the muriatic acid.

9. By mixing cold, in a well ſtopped veſſel, a ſmall quantity of this metal with 100 times its weight of concentrated ſulphuric acid, the latter gradually aſſumes a beautiful crimſon red colour. By means of a ſmall quantity of water added drop by drop, the liquor diſappears, and the ſmall quantity of the metal diſſolved depoſits itſelf under the form of black flakes. Heat deſtroys the ſolution; it makes the red colour diſappear, and diſpoſes the metal to ſeparate in the ſtate of a white oxyd.

10. When, on the contrary, the concentrated ſulphuric acid is diluted with two or three parts of water, and a ſmall quantity of the nitric acid has been added, a conſiderable quantity of the metal will then be diſſolved. The ſolution is tranſparent and colourleſs, and is not decompoſed by the mixture of a larger quantity of water.

11. All the pure alkalis precipitate from acid ſolutions of this metal an oxyd of a white colour, ſoluble in all acids. By an exceſs of alkali, the precipitate which is formed is entirely rediſſolved. If carbonat be employed inſtead of pure alkali, the ſame phenomenon takes place, with this difference, however, that by exceſs of the latter, the precipitate formed is rediſſolved only in part.

12. Exceedingly pure pruſſiat of potaſh produces no precipitate in ſolutions of this metal.

13. Alkaline ſulphures mixed with acid ſolutions occaſion a brown or blackiſh precipitate, according as the metal is combined with more or leſs oxygen. It ſometimes happens that the colour of the precipitate has a perfect reſemblance to mineral kermes, or red ſulphurated oxyd of antimony. When the ſulphure of tellurium is expoſed on burning charcoal, the metal burns with a blue colour conjointly with the ſulphur.

14. The infuſion of nut-galls, combined with the ſame ſolutions, gives birth to a flaky precipitate, of an Iſabella colour.

15. Iron and zink precipitate tellurium from its acid ſolutions in a metallic ſtate under the form of ſmall black flakes, which reſume their ſplendour by friction, and which on burning charcoal melt into a metallic button.

16. Tin and antimony produce the ſame phenomenon with the acid ſolutions of this new metal. The precipitate formed by the antimony proves, in a ſtriking manner, that tellurium is not a diſguiſed antimony, as has been ſuppoſed. A ſolution of tin in the muriatic acid, mixed with a ſolution of tellurium in the ſame acid, produced alſo a black and metallic precipitate.

17. The oxyd of tellurium obtained from acid ſolutions by alkalis, or that from al-

kaline ſolutions by acids, are both reduced with a rapidity reſembling detonation, when they are expoſed to heat on charooal. It burns and is volatilized, as ha been already mentioned.

18. By heating for ſome time this oxyd of tellurium in a retort, it melts and appears after cooling with a yellow ſtraw colour, having acquired a ſort of radiated texture.

19. Mixed with fat bodies, the oxyd of tellurium is perfectly reduced by the method formerly mentioned.

The mine of white gold of Fatzebey, *aurum problematicum*, contains tellurium, 925,5; iron, 72,0; gold, 2,5—Total, 1000,0.

The graphic gold of Offenbanza contains tellurium, 60; gold, 30; ſilver, 10—Total, 100,0.

Ore from the mine known under the name of the Yellow Mine of Nagyag, contains tellurium, 45; gold, 27; lead, 19,5; ſilver, 8,5; ſulphur, one atom—Total, 100,0.

Ore from the mine known by the name of the Mine of Grey Foliated Gold of Nagyag contains lead, 50; tellurium, 33; gold, 8,5; ſulphur, 7,5; ſilver and copper, 1—Total, 100,0. *Philoſophical Magazine*, N°. I. p. 78.

CONCERNING TITANIUM.

KLAPROTH, in his analyſis of the red ſchorl from Hungary, has announced the diſcovery of a new metal, to which he gives the name of *Titanium*. This ſubſtance appears to be the ſame with that which Mr. M'Gregor found in an iron ore from Menakan in Cornwall, and of which he publiſhed a very full and intereſting account in Crell's Journal for the year 1791. The character by which this ſubſtance ſeems to be chiefly diſtinguiſhed from other metallic ſubſtances, is in its forming a brown, red, or orange coloured precipitate with the infuſion of nutgalls. Hitherto this ſubſtance has not been obtained in its metallic ſtate. The following are the principal varieties of the titanium in its native ſtate, which have been deſcribed by mineralogiſts.

I. Ore of titanium, A. The ſubſtance uſually called *red ſchorl* from Hungary, is found cryſtallized in four ſided priſms, which have their ſides ſtriped, and in ſmall needle ſhaped cryſtals. B. Ore of titanium from Spain in light reddiſh brown ſix ſided priſms, terminated with hexahedral pyramids. C. Ore of titanium in dark reddiſh brown four ſided cryſtals, firſt deſcribed by Prince Gallitzin in his Traité de Mineralogie.

II. The titanit, ſmall cryſtals of this ore are found in a kind of ſienit at Paſſau in Germany. From a 100 parts of this ſubſtance, Klaproth obtained 33 of oxyd of titanium, 35 of ſiliceous earth, and 33 of lime, with a very ſmall portion of mangangeſe.

III. Eiſen-titanium, or ſidero-titanium. In ſmall round ſmooth grains, which retain ſome marks of a cryſtalline form. In a 100 parts of this ore, Klaproth found 84 of oxyd of titanium, 14 of oxyd of iron, and two of oxyd of manganeſe.

IV. Titan-eiſen, or titano-ſiderum, A. Menakanit from Cornwall, in greyiſh black grains, attractible by the magnet. From a 100 grains of this ſubſtance Mr. M'Gregor obtained iron magnetic with a ſmall portion of manganeſe, 46 9-16

	Oxyd of titanium,	45
	Siliceous earth,	3 1-2
Klaproth.	Iron,	52
	Oxyd of titanium,	45,25
	Siliceous earth,	3,50
	Manganeſe,	0,25

B. Titan-eiſen from Aſchaffenburg in Spain. This ſubſtance afforded Klaproth, by analyſis, 22 parts in the 100 of oxyd of titanium, and 78 of oxyd of iron.

The titanium is likewiſe ſaid to have been found in an iron ore from the Iſland of Ceylon, and in various parts of France.

According to Klaproth, the oxyd of titanium diſſolves readily in warm diluted ſulphuric acid, and forms with it a clear ſolution, which, by evaporation in the open air, is converted into a white muddy gelatinous maſs.

The nitric acid alſo diſſolves this oxyd. The ſolution acquires an oily conſiſtence by ſpontaneous evaporation, in which ſmall tranſparent cryſtals are depoſited, the primitive form of which appears to be an elongated rhombus, paſſing into the ſix ſided table by the truncation of the two oppoſite acute angles.

The ſolution of the titanic oxyd in muriatic acid afforded to Klaproth, by ſpontaneous evaporation, a clear yellow coloured jelly, in which a quantity of very ſmall cryſtalline grains of a cubic ſhape were gradually formed.

Theſe ſolutions contained from 3-100 to 5-100 parts of ſiliceous earth. Klaproth conceives that a ſtill greater quantity of this earth enters into the ſolution, producing the gelatinous appearance, and preventing the metallic ſalt from aſſuming a regular form.

When the carbonat of potaſh was added to the acid ſolutions of titanium, a white light flaky precipitate was produced.

Cauſtic ammoniac occaſioned a ſimilar precipitate.

Pruſſiat of potaſh produced a copious precipitate of a graſs green colour mixed with brown.

Gallic acid produced a voluminous brown red coloured precipitate. When this ſolution was not too much diluted with water, it became coagulated like blood. The precipitate after being collected, waſhed, and dried, had the appearance of mineral kermes (red ſulphurated oxyd of antimony). Fifteen grains of this precipitate were expoſed in a retort to a weak fire; it reſumed its white colour, and loſt ſeven grains of its weight.

The arſenic and phoſphoric acids produced a white precipitate in the acid ſolutions of this oxyd.

Tartaric acid produced alſo a white precipitate, but the precipitate in this caſe was ſoon rediſſolved. Similar phenomena took place with the oxalic acid.

A rod of tin was introduced into the muriatic ſolution. After ſome minutes, a pale roſe colour appeared round the tin rod, which at laſt was changed into a beautiful amethyſtine colour.

Into another portion of the ſame ſolution, diluted with ſix parts of water, a rod of zink was introduced. The ſolution became at firſt of a violet, and afterwards of an indigo blue colour. When rediſſolved in muriatic acid, the precipitate again exhibited the ſame appearances.

With Hahneman's hepatized acid liquor (ſolution of ſulphurated hydrogen, containing a few drops of muriatic acid), the muriatic ſolution of titanium remained unchanged.

Sulphure of ammoniac occaſioned a blueiſh green precipitate; in the dry way a browniſh green.

Fifty grains of titanic oxyd loſt, by expoſure to the fire, 12 grains of its weight; while warm it had a ſulphur yellow colour, which diſappeared during cooling. By this proceſs the oxyd became inſoluble in acids.

Expoſed on burning charcoal, the oxyd of titanium became reddiſh, and afterwards of a ſlate blue colour. A button was formed, which, after cooling, had a finely radiated ſurface. It exhibited the ſame appearances with phoſphoric ſalts, borax, and ſoda. Applied to the ſurface of porcelain with a proper flux, it produced a beautiful ſtraw coloured enamel. Klaproth endeavoured to reduce this oxyd, by mixing it with half its weight of colophonium (or black reſin), and by expoſing the mixture to a ſtrong heat, but without effect. After the flame had ceaſed, the titanium remained in the form of a white oxyd. Klaproth concludes the titanic oxyd to be of a metallic nature, from its becoming of a yellow colour by expoſure to a glow heat, and of a blueiſh by heating it in contact with charcoal; from its communicating a yellow colour by melting it with other bodies; from its being precipitated from its ſolution in acids by pruſſiat of potaſh, gallic acid, and alkaline ſulphures; from its being precipitated from its acid ſolutions, by tin and zink; from the ſtrong tendency which it ſeems to have to combine with oxygen; from its being inſoluble in acids, when fully ſaturated with oxygen, and from its becoming ſoluble when a portion of the oxygen has been abſtracted by heating it with an alkali. Klaproth remarked, that the precipitate, heated with a ſmall quantity of alkali, was not ſo white as that heated with a larger quantity, and that the former precipitate diſſolved only in a very imperfect manner in muriatic acid, but not at all in ſulphuric or nitrit acids. This chemiſt alſo conſiders the change of colour from the blue to the white which the precipitate by zink undergoes from expoſure to heat, as an effect depending on the abſorption of oxygen.

This account of the properties of the titanic oxyd by Klaproth, agrees almoſt in every particular with that given by Mr. M‘Gregor. The latter chemiſt remarks, that water, by ſtanding for ſome hours over oxyd of titanium, acquires an opal colour. The nitre and oxygenated muriatic acids ſeemed to him to have only a very weak action on this ſubſtance. Mr. M‘Gregor heated this oxyd with double of its weight of ſulphur, but the oxyd did not appear to ſuffer any change either in its weight or colour. Heated with microcoſmic ſalts, or borax, this oxyd gave a purple tinge to the mixture, ſimilar to that produced by oxyd of manganeſe. This colour diſappeared in the exterior flame of the blowpipe, and could not be made to re-appear again. The moſt remarkable fact reſpecting this ſubſtance, obſerved by Mr. M‘Gregor, is the property which it has of preventing the formation of Pruſſian blue by the addition of pruſſiat of potaſh, and of ink by the addition of gallic acid, when diſſolved in the ſulphuric ſolution of iron. Is not this effect produced by the oxyd of titanium abſtracting a portion of oxygen from the iron, and in this way reducing the iron to its minimum of oxydation? The experiment does not ſucceed with the nitric ſolutions of iron and titanium. *Klaproth's Beiträge*, B. I. ſ. 233, 245, B. II. ſ. 222. *M‘Gregor, Journ. de Phyſ.* Tom. XXXIX. p. 72, 152. *Emmerling Lehrbuch der Mineralogie*, B. III. ſ. 372. *Lampadius neues Begmanniſches Journ.* 1795, B. I. ſ. 248.

Since the foregoing account of titanium was ſent to the preſs, I have ſeen a memoir on the ſame ſubject by Vauquelin and Hecht, inſerted in the 15th Number of the *Journal des Mines.* The exiſtence of titanium, as a diſtinct metallic ſubſtance, is fully confirmed by the reſearches of theſe chemiſts, but there is a conſiderable difference in ſome of the reſults which they have obtained.

100 parts of a *red ſchorl*, found in France, were reduced to powder and melted in a crucible with 600 of carbonat of potaſh. By dilution with boiling water, this melted maſs afforded a whitiſh precipitate, which, after being waſhed and dried, weighed 157 parts. The alkaline liquor contained only a ſmall portion of ſilex and alumine, which it ſeemed to have taken from the crucible; it held cauſtic potaſh in ſolution, and the precipitate itſelf poſſeſſed the property of effervescing with acids. This precipitate loſt 0,25 of its weight by expoſing it ſimply to a ſtrong heat. Vauquelin and Hecht, therefore, conſider this precipitate as a combination of the metallic oxyd with carbonic acid, and call it the *carbonat of titanium.*

An effervеſcence was produced by boiling 12 grains of this carbonat in ſulphuric acid. The liquor, which at firſt had a milky appearance, became clear by an increaſe of temperature.

A rapid diſengagement of carbonic acid was produced by mixing 25 parts of carbonat of titanium with concentrated nitric acid. When the mixture began to grow warm, a conſiderable quantity of nitrous gas was formed, yet the mixture always retained a milky appearance. By employing a diluted acid, without the application of heat, the oxyd of titanium was completely diſſolved, but it was again depoſited by expoſing the ſolution to heat.

A ſimilar diſengagement of carbonic acid took place by mixing the white precipitate with muriatic acid. The ſolution in the cold was perfectly clear; but it ſoon aſſumed a gelatinous appearance by the application of heat. The ſmell of oxygenated muriatic acid could be diſtinctly perceived during the depoſition of the oxyd of titanium in boiling muriatic acid. Suſpecting that in this proceſs the oxyd had loſt a portion of its oxygen, in conſequence of which it became inſoluble in muriatic acid, theſe chemiſts digeſted this oxyd in the cold with muriatic acid; but no combination took place, though muriatic acid diſſolved readily in the ſame circumſtances the oxyd of titanium, which had been precipitated from boiling nitric acid. It would ſeem, therefore, that the oxyd of titanium unites with the nitric and muriatic acids in two different ſtates of oxydation; with the nitric, when not fully ſaturated with oxygen and with the muriatic acid, only in a high ſtate of oxydation.

12 parts of carbonat of titanium, boiled with a 100 of acetous acid, did not exhibit any appearance of effervеſcence, though the liquor aſſumed a milky colour, and though it was evident, from the effect of reagents, that the acid had diſſolved a portion of the carbonat of titanium.

The pruſſiat of titanium, which is of a green colour, is decompoſed by alkalis, and paſſes through different ſhades of purple and blue till it becomes finally white.

By treating carbonat of titanium with a variety of fluxing bodies, Vauquelin and Hecht obſerved it repeatedly aſſume a metallic appearance; but, like many other metallic ſubſtances, it appeared to be volatile in a high degree of heat. A ſmall portion of this metallic titanium was boiled for a long time with pure nitric acid; and though there was no very marked action between theſe ſubſtances, yet the ſhining metallic points diſappeared, and a whitiſh matter appeared in their place. A whitiſh powder was formed by digeſtion with nitro-muriatic acid. Vapours of ſulphureous acid were diſengaged during this ebullition of the metallic titanium in ſulphuric acid, and the titanium changed into a whitiſh powder, part of which remained diſſolved in the ſulphuric acid. In one experiment with diluted muriatic acid, hydrogen gas was evolved, and a conſiderable quantity of a white flaky matter produced in the liquor.

END OF VOL. II.

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